REPORT RESUMES

ED 002 889 24

AN ANALYSIS OF THE FACTORS RELATED TO THE MOTIVATION AND ACHIEVEMENT OF STUDENTS IN SCIENCE COURSES IN THE JUNIOR AND SENIOR HIGH SCHOOL, FINAL REPORT.

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REPORT NUMBER CRP-503 PUB DATE 63
EDRS PRICE MF-$0.36 HC-$8.12 203P.

DESCRIPTORS- *HIGH SCHOOL STUDENTS, *STUDENT MOTIVATION, *ACADEMIC ACHIEVEMENT, *SCIENCE COURSES, *TESTING PROGRAMS, FACTOR ANALYSIS, INTELLIGENCE, READING ABILITY, INTERESTS, STUDENT TEACHER RELATIONSHIP, PARENT INFLUENCE, TEACHING METHODS, KALAMAZOO, MICHIGAN

A 6-YEAR INVESTIGATION WAS MADE TO IDENTIFY THE FACTORS THAT (1) RELATE TO THE ACHIEVEMENT IN SCIENCE OF STUDENTS IN JUNIOR AND SENIOR HIGH SCHOOL AND (2) MOTIVATE STUDENTS TO ELECT COURSES IN SCIENCE AT THESE LEVELS. TO OBTAIN THE REQUIRED DATA, THE INVESTIGATOR SELECTED APPROXIMATELY 2,500 STUDENTS WHO ENTERED THE SEVENTH GRADE IN THE FALL 1957 IN 12 SCHOOL SYSTEMS AS SUBJECTS FROM THAT TIME THROUGH THEIR SENIOR YEAR OF HIGH SCHOOL. NUMEROUS MEASUREMENTS WERE MADE DURING THE PROJECT INCLUDING--(1) THE MENTAL ABILITY, READING ABILITY, EDUCATIONAL PLANS, INTERESTS, AND SCIENCE ACHIEVEMENT OF THE STUDENT SUBJECTS, (2) THE ACADEMIC BACKGROUND AND PERSONALITY FACTORS OF THEIR TEACHERS, AND (3) CERTAIN CHARACTERISTICS OF THEIR FAMILIES, SCHOOL SYSTEMS, AND COMMUNITIES. THE CONCLUSIONS AND IMPLICATIONS DRAWN FROM THESE MEASUREMENTS WERE GROUPED UNDER SUCH HEADINGS AS--(1) SCIENCE ACHIEVEMENT AND THE SCHOOL, (2) STUDENT FACTORS, (3) HOME, SCHOOL, AND COMMUNITY FACTORS, AND (4) TEACHER FACTORS. THE MOST INFLUENTIAL FACTOR IN SCIENCE ACHIEVEMENT SEEMED TO BE THAT OF ASPIRATIONS AND INTEREST OF PARENTS FOR THE EDUCATION OF THEIR CHILDREN. NO SINGLE TECHNIQUE WAS SUGGESTED FOR THE PROBLEMS OF IMPROVED SCIENCE TEACHING OR SCIENCE COUNSELING, ALTHOUGH MANY POSSIBILITIES WERE PRESENTED. (JH)

ED 002889

accepted 1-7-65

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INTRODUCTION

Science Motivation Project I was initiated in 1957 because the Project Director did not hold the belief, popular in the early 1950's, that only a small proportion of high-ability students enter the scientific professions upon graduation from college. The Director also challenged the prevailing idea that only those students with high intelligence quotients could contribute successfully to scientific and technological developments in the United States. There was ample evidence at the time to suggest that neither of these basic assumptions, although plausible, were defensible. However, there were few who investigated the data that were available in order to draw objective conclusions.

Consequently, a long-range study to investigate the validity of these and related assumptions began in January 1957. The first major step, Science Motivation Project I, terminates with this report. Beginning January 1, 1959 fiscal support for the Project was obtained through the Cooperative Research Program, Office of Education. During the course of the Project, the public-school systems of Rockford, Kankakee, and Wilmington, Illinois; Elkhart, Angola and Kendallville, Indiana; Bryan and Archbold, Ohio; Kalamazoo, Marshall and Quincy, Michigan; and the University High School, Kalamazoo, Michigan participated in the various aspects of the Project which are described later in this report.

It would be impossible in the space available here to list all of the persons who contributed to the development of the Project or to describe their contributions. A few of those with whom the Director dealt personally are found in Appendix A. Many others, including the students who served as subjects, unfortunately could not be listed. Nevertheless, without their cooperation and that of the Administration and other units of Western Michigan University, and the monetary support from the Cooperative Research Program, it is unlikely that this study could have been completed. To the persons who are listed and to the many more who are not cited, the Project Director wishes to extend his sincere appreciation.

George G. Mallinson,
Project Director.

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CHAPTER I

THE RATIONALE OF SCIENCE MOTIVATION PROJECT I

The Purpose of the Study

The purpose of the study, for which support was received under Grant #503 of the Cooperative Research Program, was to make a long-term investigation of the factors that (1) may be related to the achievements of the students in courses in science in junior- and senior-high schools; and (2) motivate students to elect courses in science at these levels.

The Background of the Study

Since World War II there has been great concern in the United States with problems related to the teaching of science and mathematics. The concern has been directed toward many different factors that have contributed to the problems. Some of these factors have been identified and attacked successfully. Unfortunately, many contributing factors have not been generally recognized and consequently have not been understood. Prior to, during, and after World War II, it was evident to those who had been studying the population distribution and manpower needs of the United States, that there was an impending and long-term shortage of scientifically- and technically-trained personnel. During World War II, obviously, there had been a need of staggering dimensions for scientifically- and technically-trained personnel to maintain the war machine. No one really knows whether this need was or was not met. Suffice to say the war was won. For a short period around 1950-52 there was some concern that there was an oversupply of personnel trained for industrial and teaching positions in science and technology. However, two major considerations of immediate importance were generally ignored. The first was that the United States would remain on a semi-mobilized basis for an indefinite period. Consequently the demand for technically-trained personnel for the military establishment would not diminish. Further, the "Space race" and the accompanying need for scientific personnel had not even been anticipated.

The second factor concerned the information explosion in science and the consequent impact of new scientific knowledge on all segments of the culture. Prior to 1940 it was estimated that scientific information was doubling in volume every fifty years. During the 1950's, with the advent of the digital computer, it was estimated that scientific information was doubling in volume every ten years. In the 1960's the growth rate has apparently increased to a doubling of volume every seven years. Consequently the growing need for scientific and technological personnel, and the burgeoning domain of science made the trained manpower pool numerically insufficient.

The shortages of scientifically- and technically-trained personnel affected science teaching from the elementary through the college levels. In particular, it was impossible to staff all the positions in science and mathematics in the junior- and senior-high school with teachers who had the necessary specialized training. Further the flood of scientific information had made much of the content of these courses obsolescent. A number of efforts, some of them ill-considered, were undertaken to alleviate the situation. As frequently happens, blame for the shortage of scientifically- and technically-trained personnel was placed on public education. Many persons whose intellectual integrity was difficult to challenge claimed that the schools were not meeting their responsibilities in providing high-caliber training in science. Consequently recriminations for the shortages could be directed toward school teachers, school administrators, teachers college and "progressive education." In many places a "crash effort" was made to direct as many "talented students" as possible into the fields of science and mathematics and to upgrade programs of science teaching. No sensible person will challenge the merits of upgrading science and mathematics programs at all levels of educational matrix. However, many of the assumptions on which the efforts were based were not supported by the facts. Two of these erroneous assumptions follow:

1. It has been said frequently that inferior science teaching in the elementary and secondary schools caused great numbers of talented students to avoid science courses. Consequently these students did not enroll science and mathematic courses in college. However, facts completely discredit such a belief. Data supplied to the writer in 1955 by a staff member of the National Science Foundation indicated that as many as 60% of those students with IQ's of 135 or higher, on leaving college, enter professions in the various fields of science and technology. One may rightly suggest that the number of students in this category of ability is relative small. However, if the criterion IQ is reduced to an IQ Score of 115 or better then data supplied by studies undertaken by Strauss, Brechbill and Mallinson indicate that 34% of the students in this superior group enter science and technology on graduation from college. When one considers that the number of persons employed in the scientific and technological professions make up somewhat less than 20% of all professional persons, then it does seem that science and technology are getting their share of talented students.

   The real tragedy, however, lies elsewhere. Data that are available, although as yet somewhat incomplete, indicate that of the educable group (IQ's 100-115) who complete college, only about 7% enter the fields science and technology on graduation. Yet the number of such personnel is far greater than that talented pool.

2. When the term "talented student" is used, the general impression given is that "talented students" represent a truly fertile field for the education of personnel for careers in science and technology. However, talent for science and mathematics is too often considered

> synonymous with a high intelligence score. Such beliefs are to some extent true. Yet, psychological studies show that many persons with high intelligence scores have no aptitude or interest whatsoever for these fields. Even more disturbing is that students with average or slightly better than average ability are generally considered as lacking potential for science and mathematics. Yet much evidence now available indicates that vast numbers of this group have great potential for science and mathematics and are being lost through ill-advised attitudes of recruiters many of whom are scientists and mathematicians. For example, data collected by Strauss, Brechbill and Mallinson point out that many persons with IQs below 115 have achieved eminence in scientific fields.
>
> The studies of Pelz involving the social motivation of scientists and engineers indicate that factors other than intelligence have great influence on productivity in the fields of science and engineering. In fact the data suggest that once such a specialist is acclimated to his position, his productivity, either as an individual or a member of a project group bears little relationship to his intelligence. It may be pointed out that there is little likelihood for meeting the needs of scientifically- and technically-trained personnel by merely recruiting more talented students. Simple computations indicate that if all the students with IQs of 115 or higher not now entering science and technology were to be directed into these fields the number available would meet less than 20% of the estimated needs.

One other issue related to the shortages concerns the caliber of the science-teaching profession. The many untrained, and inadequately-trained teachers, in the science classrooms were alleged to be victims of programs offered by teachers colleges, that were devoid of subject-matter content, lacked "educational standards," and were "loaded with requirements in courses in professional education averaging at least 75% of the total offerings." Without any effort to debate this point of view, the writer suggests that the significance of another situation, even more real, had not been perceived. There weren't enough "warm bodies" to train either in good or bad programs in teachers college, or for that matter in any institution of higher education. It was a simple fact that the "battle of the bedroom" had been lost between 1930 and 1945 when the birthrate was about 60%

of what might have been expected. Table I below contains the evidence:

Table I

College-Age Population by Year*

Year	Number
1939	8,700,000
1953	5,400,000
1962	8,700,000

*These data are abstracted from information collected by the Department of Defense and include persons in the 17-21 age range.

The data in the table are particularly significant in that in 1939 the total population of the United States was about 130 million and in 1962, about 184 million.

In general, a college-age population becomes stabilized in the occupational matrix in about 10 years. Thus, in 1949, the 1939 group that was "stabilizing" had to serve a college-age group somewhat smaller than itself. However, from 1949 on, the population of the college-age group reached the nadir of about 5,400,000. Meanwhile the number of college-age students to be served increased steadily until in 1962 the group was about the same size as in 1939. However, the population that was "stabilizing occupationally" was the one of 1953. The ratio of that service population to the new consuming population was 1 to 1.6. As a result, there has been a desperate scramble for trained personnel in all areas, particularly in education. In order to provide "warm bodies" to teach classes in science and mathematics, all types of personnel were unearthed and placed in these classrooms, as well as in classrooms for all other fields.

If professional educators and teachers colleges could be blamed for the population shortage, then much is expected of them beyond the call of duty.

Data indicate clearly that the shortage is not likely to be alleviated for many years to come, and that possibly the junior-high school will still be "a dumping ground" for many inadequately-prepared teachers. By the time the present college-age population has stabilized in the occupational matrix in 1972, the 8,700,000 in the present group will have to serve 14,600,000 students of college age. The ratio will then be 1 to 1.7 which is less advantageous than the present 1 to 1.6. Support forthis statement is found in projections prepared by the NSF and which appear in a table entitled "Science and Mathematics Teachers Requirements, Turnover, Recruitment, and Training Opportunities Offered by the Institute Section, National Science Foundation." An analysis of the data in the table indicate that by 1969 the secondary-school student is more likely to meet with an inadequately prepared science or mathematic teacher than at present.

Because of these various anomalies this investigator decided to undertake a long-term study to determine what factors might be responsible for the motivation and achievement of students who do enter the fields of science in the hopes that the findings might lead to a more-adequate solution for the shortages.

Other Related Research

There have been a number of research investigations undertaken concerning interests of students in the fields of science and the factors that motivate them to elect careers in this field. Among the more significant studies are the following:

Bowman, Paul H.; DeHaan, Robert F.; Kough, John K. and Liddle, Gordon P., *Mobilizing Community Resources for Youth*. Supplementary Educational Monographs, Number 85, the University of Chicago Press, October 1956. Pp. viii + 138. (Quincy Youth Development Project).

Brandwein, Paul F., "Selection and Training of Future Scientists." *Scientific Monthly*, LXIV (March 1947), 247-52.

Carlin, Benjamin B.; Del Santo, Louise M.; Gordon, John L.; Johnson, Charles A. and Nash, Malcolm F., "Reactions of Selected Pupils on Inquiry Forms and Personal Interviews Seeking to Discover Present Interests and Attitudes in the Science of Their Own Age Level." Unpublished master's thesis, Boston University, 1954.

Coleman, James, "Adolescent Subcultures and Educational Values." A research report of motivational factors affecting high school students presented at the meeting of the American Sociological Society, Seattle, Washington, August 27-29, 1958. Pp. 17 + tables.

Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science, "High School Science and Mathematics in Relation to the Manpower Problem." *School Science and Mathematics*, XLIII (February (1943), 126-56.

Mallinson, George Greisen and VanDragt, Harold, "Stability of High School Students' Interests in Science and Mathematics." *School Review* LII (September 1952), 362-7.

Pelz, Donald C., "Social Factors in the Motivation of Engineers and Scientists." *School Science and Mathematics*, LVIII (June 1958), 417-29.

Zim, Herbert S., "The Scientists in the Making: Some Data and Implications from the Junior Scientists Assembly." Science Education, XXXIII (December 1949), 344-51.

It is the opinion of this investigator, however, that the techniques used in many of these, as well as in other studies, have not been consistent with the implications involved. Some studies suggest that scientific aptitude consists of a complex of a high level of native intelligence, quantitative ability, and verbal ability. Other studies suggest that scientific talent can be identified by an analysis of children's questions and professed interests in science at the third-grade level. The writer challenges the findings of these studies for two basic reasons:

1. A student with a high level of native intelligence, quantitative ability, and verbal ability probably has talent for a great number of fields. There is no reason to assume that a combination of such factors uniquely represents scientific aptitude.

2. The techniques used in some studies have been essentially retrospective in nature. In general, in such studies, adults who are already engaged in scientific careers have been queried about when they first became "interested in science." Ordinarily they have indicated "around the third-grade level." Thus, the assumption has been made that if a third grader asks questions about science and professes interest in science, he has scientific aptitude and/or scientific talent. The investigator wishes to point out that nearly all psychological evidence indicates that the age of recollection of any adult for any type of interest goes back to the third-grade level. Had the adult been asked the level at which he became interested in automobiles, he probably would have stated the third grade. It may be noted further that scientists are likely to be reaction-sensitive to the fields in which they are currently employed and profess interests at a time when they did not really exist.

In this study the investigator hopes to avoid what he believes to be the pitfalls of these other investigations.

Science Motivation Project I

Science Motivation Project I was initiated by this investigator in 1956 because of the problems that had been identified with junior-high-school science and the studies that were being published concerning the identification and nurturing of science talent. In carrying out the Project, an effort has been made to trace the maturing motivations and interests of students of all levels of ability beginning with the end of the sixth grade and extending through the senior year of high school. The academic year 1962-63 was the last year of Science Motivation Project I. In the investigation no effort was made to deal only with one intellectual segment of the student bodies in the participating schools nor expect a high degree of recall from persons who probably long ago forgot the incidents that aroused their scientific interest in science. Rather all the students in the participating schools were included in the design described in the next chapter with some limitations mentioned later. In implementing the investigation it was hoped initially that answers to the following questions would be elicited.

1. What factors of intelligence are related to subject-matter achievement in the sciences?
2. To what extent is interest in science related to those factors of intelligence that seem to foster achievement in the sciences?
3. To what extent does the subject-matter training of the junior-high-school teacher influence students to elect courses in science in high school in the area in which the junior-high teacher is best trained?
4. What factors in the personality of the teacher of science seem to motivate students to elect courses in sciences in high school?
5. To what extent is achievement in junior-high-school science related to achievement in courses in high-school science?
6. To what extent does achievement in junior-high-school science seem to influence students to elect courses in high-school science?
7. How does general student interest in science change from the sixth-grade level through the high-school level?

A number of other related questions were considered as the investigation progressed these are presented in later sections of the report.

CHAPTER II

THE DESIGN OF THE STUDY

Purpose

The purpose of this chapter is to describe the various elements of the design developed for Science Motivation Project I.

Selecting the Participating Schools

In order to obtain the data for answering the questions listed in the previous chapter, the investigator decided to select schools that were representative of rural, semi-urban, and urban communities in the United States. Because of the anticipated need of working closely with the schools during the six years of the Project it was decided to select schools located in the states of Illinois, Indiana, Ohio and Michigan. The investigator conferred with the Superintendents of Public Instruction of these four states to obtain information about certain public schools that he had tentatively selected. With the advice and cooperation he received from these administrators it was decided that an effort would be made to seek the participation of the school systems of Rockford, Kankakee and Wilmington, Illinois; Angola, Elkhart and Kendallville, Indiana; Archbold, Bryan and Toledo, Ohio; Marshall, Quincy and Kalamazoo, Michigan, and the University High School at Western Michigan University. Between January 1, 1957 and April 1, 1957 personal visits were made by the investigator to these school systems. The rationale of Science Motivation Project I and the tentative design were discussed with the superintendents and other personnel that might be involved and the commitments that would need to be made were analyzed extensively. Of the schools that were approached, all agreed to participate except Toledo, Ohio. After consultations with a number of other research workers, the principal investigator decided that the school systems enlisted for participation constituted an adequate sample. Consequently no further efforts were made to enlist the cooperation of other schools. The tentative design that was discussed included these facets. (Note: It was emphasized that the proposed investigation was analytical in nature. Consequently, the participating schools were not expected to make any changes whatsoever in their curricula, or administrative procedures.)

1. About 2,500 students from a geographical sampling of schools in Illinois, Indiana, Michigan, and Ohio would participate. Assuming fifty percent of the students participated throughout the study, complete sets of data would be available for about 1,300 of them at the conclusion of the study in 1963.

   The testing program described later would begin in the spring 1957 when the participating students were completing the sixth grade, or in the fall 1957 when they entered the seventh grade. It would continue throughout their secondary-school careers. During the seventh, eighth and ninth grades, all children in the participating schools would be tested. Beginning with the tenth grade, only those students electing science courses would be included in the testing program. The tests would be scored and analyzed at Western Michigan University without cost to the participating schools. During the course of the study, results of the tests would be made available to the participating schools. Further the schools would be kept informed of the progress of their students. Only one group of students would participate over the period of the six-year study. The study would not involve all students in all the six grades during the six-year span.

2. The science courses elected by the teachers of these students, both at the graduate and undergraduate levels, would be obtained by examining transcripts. With these data, an attempt would be made to determine the relationships that might exist between the teachers' backgrounds and (a) achievements of their students, and (b) the extent to which the students elect additional courses in the sciences beyond those required.

3. The teachers of science in the participating schools would be requested to complete the Personal Audit and in addition it was contemplated that a rating would be checked by the supervisors of these teachers in order to determine certain of the personal characteristics of these teachers. An attempt would be made to identify any relationships that might exist among the characteristics thus identified and (a) the achievements of their students in science, and (b) the extent to which the students elected courses in science later.

The Collection of Data

With the assistance of William M. Crumrine of the Marshall Public Schools, Marshall, Michigan, who served as Assistant Project Director, as well as with that of other research workers, a testing program was developed. During the course of the study changes that seemed desirable were made in the original testing program. The program that was implemented between 1957 and 1963 appears in Table II.

On May 1, 1957 the testing program described in Table II began. The first test in the study, the SRA Junior Inventory was administered to sixth-grade students in Kalamazoo, Michigan; Bryan, Ohio; Wilmington, Illinois who would participate in the study as seventh graders during the following fall. During September and October 1957, the seventh-grade students in the other participating school systems were administered the test. Not every student in the participating school systems was a subject in the Project. In those school systems in which there were two or more high schools, one high school was selected for participation. Only the students in the junior-high schools that "fed" that high school were included in the testing program during the first three years.

During the first three years, in so far as possible, every student was administered all the tests, whether or not he was enrolled in a science course. During the last three years a minor change was made in the original plan. In so far as possible, every student in the participating classes was administered

Table II

The Testing Program for
Science Motivation Project I*

Year	Intelligence Tests	Reading Tests	Interest Tests and Inventories	Achievement Tests
1957-58	SRA Primary Mental Abilities: Intermediate Form		SRA Junior Inventory: Form AH	SRA Achievement Series: Science Part I (1958) and Science Part II (1958) SRA Achievement** Series: Arithmetic (Grades 6-9)
1958-59		Diagnostic Reading Test: Form A	SRA Junior Inventory: Form AH	SRA Achievement Series: Science Part I (1958) and Science Part II (1959) SRA Achievement Series: Arithmetic (Grades 6-9)
1959-60	SRA Primary Mental Abilities: Intermediate Form		Your Educational Plans	SRA Achievement Series: Science Part I (1958) and Science Part II (1959) SRA Achievement Series: Arithmetic (Grades 6-9) Nelson Biology*** Test

Table II (continued)

Year	Intelligence Tests	Reading Tests	Interested Tests and Inventories	Achievement Tests
1960-61			Kuder Preference Record: Form C	Nelson Biology Test Tests for General Physical Science
1961-62	SRA Tests of Educational Ability: Grades 9-12		Kuder Preference Record: Form C	ACS-NSTA Chemistry Test (1961)
1962-63		Diagnostic Reading Test: Form A	Kuder Preference Record: Form C	Dunning Physics Test

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[*] The bibliography of tests used, with complete citations, is found in Appendix B.

[**] The SRA Achievement Series: Arithmetic was an "extra" test not planned originally in the testing program. However, in several schools the personnel agreed to administer the tests at the end of the year. The scores that were obtained were used in determining any relationships that might exist between achievements in science and mathematics.

[***] The achievement tests listed were those administered to most of the student participants. However some modifications were made to accomodate different schools. In some schools Biology was taught in the ninth grade rather than in the tenth. In some physics was taught in the eleventh grade and chemistry in the twelfth. In one school, a group of seniors enrolled in an advanced placement science seminar were administered the Comprehensive Scholarship Examination in Science and Mathematics used at Western Michigan University. Several tests for special science courses, for example a combined earth science and biology course for freshman in one school system, were also prepared. Their use will be discussed in the later analyses.

every test listed except the science achievement tests. Only those students enrolled in science courses were administered the appropriate science tests. No effort was made to eliminate students who entered the participating classes after the study began. The scores they obtained on the tests were used where appropriate.

The tests, other than the achievement test, were administered as early in the fall semester as possible. The achievement tests were administered as late in the spring semester as possible.

Generally, the transcripts of the teachers were analyzed, and their science and mathematics backgrounds recorded on rosters late in the spring semester each year of the Project. No problem arose in obtaining this information. Late in the spring semester for the first three years of the Project the teachers were contacted concerning their willingness to complete the Personal Audit. Except in one participating school, nearly all the teachers agreed to cooperate. Usable replies were received from nearly 90% of the teachers.

As indicated earlier, the Director visited every participating school system at least three times annually. During these visitations the Director had the opportunity to review the science programs and obtain subjective data that were useful in interpreting the results of the analyses. It was during these visits that the Director obtained sufficient information about the teachers to make it unnecessary for their supervisors to fill out check sheets concerning their characteristics.

Table III indicates the number of students participating annually in the cooperating schools for whom usable records are available.

Table III

Number of Students Participating

	Number of Students Participating					
School System	**1957-58**	**1958-59**	**1959-60**	**1960-61**	**1961-62**	**1962-63**
Angola	123	111	147	138	116	95
Archbold	53	50	68	65	69	66
Bryan	142	128	134	131	119	112
Elkhart	234	195	178	138	601	229
Kalamazoo	499	460	396	689	324	180
Kankakee	354	334	373	339	100	63
Kendallville	140	112	145	124	122	105
Marshall	188	181	191	182	73	72
Quincy	112	94	94	71	79	75
Rockford	587	493	552	871	704	638
University	61	58	76	83	84	79
Wilmington	108	96	119	120	62	16
Total	2,601	2,312	2,473	2,951	2,453	1,730

Tabulating and Analyzing the Data

It was planned originally to analyze the data with the typical desk calculators using the services of statistical assistants. However, in 1960 Western Michigan University acquired an IBM 1620 System with extensive auxiliary equipment. With the assistance of Dr. Bertram A. Masia formerly with Science Research Associates and now a staff member of the Department of Education, University of Chicago, rosters were prepared for each year of the Project on which the scores of the students were recorded. The data on these rosters were then punched in IBM Cards which were used in making the analyses described in the later chapters of this report.

Rapport with the Participating School Systems

It should be mentioned that the Director was asked to assist with many activities in the participating school systems some directly related to the Project, and some not so directly related. He offered various kinds of consulting services to the science and mathematics programs, assisted the schools in obtaining consulting services in other academic areas, and spoke at a number of commencement exercises and community programs. In addition, many of the superior students from the participating school systems were accepted in Summer Science Training Programs and Cooperative College-School Programs sponsored by Western Michigan University with the support of the National Science Foundation. In effect the rapport between Western Michigan University and the participating schools was superior.

CHAPTER III

THE PARTICIPATING SCHOOLS AND THE SCIENCE ACHIEVEMENT TESTS-1957-60

The Program

The purpose of this chapter is threefold, namely to describe (1) the characteristics of the SRA Achievement Series-Science used to measure science achievement during the first three years of the Project; (2) some of the characteristics of the participating schools and their general-science programs as viewed subjectively by the Project Director; and (3) some of the relationships that seemed to exist between the characteristics of the participating schools and the scores the students obtained on the science achievement tests.

The SRA Achievement Series-Science

Science Motivation Project I was a six-year longitudinal study in which an attempt made to delineate some of the bases of science interest and achievement. Consequently no attempt was made to manipulate or control in any way the science curricula in the participating schools. In order to implement the Project once the participating schools were selected, it was necessary to obtain a measure of science achievement that would meet these criteria:

1. Assess the attainment of various objectives of science instruction, not just retention of scientific facts.
2. Have a broad enough range of items to measure achievement in general science across grades 7, 8 and 9.
3. On the basis of data available, evidence satisfactory degrees of validity.

An examination of the commercial tests that were available failed to reveal that any of them met the criteria satisfactorily. Those that were available were either too short, too old, failed to measure objectives other than factual retention, and/or in the opinion of the Project Director, failed to evidence either reliability or validity.

However, the Project Director discovered that tests were in preparation that seemed to meet the criteria desired, namely the SRA Achievement Series-Science Part I and Part II.[1] The experimental editions that were available had already been tested in a number of schools and the available data concerning their reliability seemed to suggest that they would be suitable. Part I ("Knowledge") consisted of 109 items and was available in the 1958 Experimental Edition. A typical item follows:

> "If a fire burned over the sides of a mountain, what is likely to happen in the valley below in the next few years?
>
> A. Earthquakes
> B. Floods
> C. More fires
> D. Nothing of importance."

Part II ("Concepts") consisted of two forms, the short form, or the 1958 Experimental Edition, with 27 items; and the long form, or the 1959 Experimental Edition, with 36 items (the short form plus 9 additional items). The short form was used in the testing program 1957-58, and the long form in 1958-59 and 1959-60. A typical item on Part II follows:

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[1] It is appropriate to acknowledge here that the administrative officers of Science Research Associates approved a 50% research discount for tests and other materials purchased from that organization for Science Motivation Project I. The discount enabled the Project Director, within the financial support available, to make many more analyses than would otherwise have been possible.

"THE AQUARIUM AT SCHOOL

The boys and girls in Miss Adams class have an aquarium. It has an airtight cover which they open every two days to feed the goldfish. They have been careful to put plants in the aquarium. At first the children kept the aquarium in a dark corner of the room, then moved it to the window sill. Not long afterward they noticed bubbles in the water and the plants looked greener. The plants looked healthy and green all year long.

Tom noticed that almost every morning the glass cover had drops of water hanging from it, but they soon disappeared. He wondered about this and asked his teacher what made it happen. After Christmas holidays Tom hurried to school. He wondered if the goldfish would be alive because no one had opened the cover to let in air. He was afraid the fish would be dead. To his surprise he found them living. He found them swimming about as lively as ever.

154. Why did the plants stay healthy and green all year long?

A. The plants use the waste products in the water and the sunlight to make food.

B. The water plants are colored green by nature.

C. The plants receive plenty of sunlight.

D. The plants always have plenty of water to help them grow well."

Part II of both the 1958 and 1959 Experimental Editions consists of a number of such anecdotes followed by four to six items to which the students were expected to respond.

One of the analyses for the junior-high-school science program was aimed at measuring growth in science achievement as evidenced by the scores the students obtained on Part II. Consequently at the seventh-grade level Part II was scored on the 1958 Experimental Edition. At the eighth-grade level two scores were used, namely, the score on the 27 items that appeared on both the 1958 and 1959 Experimental Editions and on the total 36 items on the 1959 Edition. Hence it was possible to make comparison between the scores obtained at the termination of the seventh- and eighth-grade programs on 27 items; and between the eighth- and ninth-grade programs on 36 items.

The Administration of the SRA Achievement Series-Science Part I and Part II

Both Part I and Part II of the SRA Achievement Series-Science were administered to the students in the participating classes at the ends of the school years 1957-58, 1958-59 and 1959-60. In so far as possible every student in the participating classes was administered the examinations without regard for his enrollment in a science course. Where possible, also, the students were administered the general-science examinations even if they elected another science in the ninth grade. In such cases the students were administered both the general-science examinations as well as the examination for the other science. In some schools students were taking biology in the ninth grade or hybrid courses in biology and earth science.

Responses to the items on the examinations were made on standard IBM sheets with electrographic pencils. The examinations were scored by machine and a sampling of every tenth IBM sheet was hand scored to check for accuracy of scoring.

A summary of the means and standard deviations of the scores obtained by the students on the general-science examinations appear in Table I. A further analysis was made of the scores by computing the interquartile ranges for each school district by grade level and part of test. The data from these analyses appear in Table II.

Table IV

Means and Standard Deviations

	PART I						PART II							
	1957-8		1958-9		1959-60		1957-8		1958-9 (short)		1958-9 (long)		1959-60	
School	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A	39.34	5.69	45.95	13.36	52.37	16.59	11.04	3.37	12.74	4.67	17.68	6.07	19.87	6.33
B	36.63	10.97	43.88	14.65	55.87	14.74	10.46	3.54	12.34	4.13	17.54	5.59	19.37	5.22
C	44.84	14.14	56.31	16.02	65.13	15.43	12.98	3.80	14.41	4.80	19.91	6.14	22.00	5.03
D	38.06	10.27	44.15	17.01	54.21	17.07	11.19	3.27	11.84	5.01	17.65	6.59	20.53	6.29
E	38.45	11.59	49.96	18.53	49.36	17.81	11.84	3.67	12.49	4.85	16.51	6.29	17.48	6.40
F	46.05	12.97	48.48	12.34	58.64	13.90	11.15	3.09	11.51	3.63	15.99	4.64	13.41	4.58
G	37.19	12.65	48.24	16.81	50.04	18.16	10.80	3.80	11.69	4.68	16.74	6.29	18.79	6.22
H	38.30	10.83	45.28	11.32	50.06	13.04	11.02	3.10	11.97	3.35	17.33	4.55	18.34	5.06
I	45.01	12.63	52.82	13.84	55.95	14.42	13.46	3.84	14.40	4.63	19.50	6.18	19.49	6.75
J	40.02	12.01	52.65	15.27	61.81	13.93	12.55	3.33	12.51	4.42	17.68	5.46	20.79	6.20
K	51.20	15.07	65.97	16.25	66.23	17.93	15.57	4.06	18.56	4.20	25.30	4.94	24.88	3.05
L	37.84	8.95	47.66	13.25	50.76	13.28	8.22	2.52	11.12	4.46	16.22	5.23	17.08	5.12

Table V

Interquartile Range By School
District, Grade Level, and
Part of Test

School District	Science Part I				Science Part II			
	Grade	Q_1	Q_2	Q_3	Grade	Q_1	Q_2	Q_3
A	7	30	37	47	7	8	10	13
	8	35	44	57	8S	9	12	15
	9	41	51	64	8L	13	17	21
					9	15	20	24
B	7	29	35	43	7	7	10	12
	8	34	42	52	8S	9	12	15
	9	44	54	67	8L	13	17	21
					9	14	18	23
C	7	34	44	53	7	10	12	15
	8	44	53	65	8S	11	14	17
	9	54	66	78	8L	15	20	24
					9	18	22	26
D	7	31	37	46	7	8	11	13
	8	35	44	56	8S	9	12	15
	9	43	53	67	8L	13	17	22
					9	16	21	24
E	7	30	36	44	7	8	11	14
	8	39	49	61	8S	9	12	15
	9	36	47	60	8L	12	17	21
					9	12	17	22
F	7	37	43	54	7	8	10	13
	8	41	46	53	8S	8	11	13
	9	47	58	67	8L	12	15	18
					9	11	13	17

Table V. (continued)

	Science Part I				Science Part II			
School District	Grade	Q_1	Q_2	Q_3	Grade	Q_1	Q_2	Q_3
G	7	28	35	44	7	8	10	13
	8	35	46	60	8S	8	11	14
	9	37	47	62	8L	11	16	20
					9	13	18	22
H	7	31	38	44	7	8	10	13
	8	36	44	53	8S	9	12	14
	9	41	49	58	8L	14	17	20
					9	14	18	21
I	7	36	43	51	7	10	13	16
	8	43	50	61	8S	10	14	17
	9	45	56	67	8L	14	18	24
					9	15	19	24
J	7	32	40	47	7	10	12	15
	8	40	51	63	8S	9	12	15
	9	44	59	74	8L	13	17	21
					9	16	21	25
K	7	39	51	59	7	13	15	18
	8	54	68	80	8S	15	18	22
	9	54	68	80	8L	21	25	28
					9	20	24	28
L	7	29	37	42	7	7	8	10
	8	38	47	57	8S	8	12	14
	9	40	51	60	8L	12	15	19
					9	13	17	20

The Reliability and Validity of the SRA Achievement Series-Science Part I and Part II

As stated earlier when Science Motivation Project I was initiated, none of the published tests that were available for measuring achievement in junior-high-school science were judged. The tests in the experimental editions that were selected seemed to have sufficient reliability on the basis of tentative data to warrant their use. Also, careful examination seemed to support their "face validity." However, at the end of the first year of the Project after the SRA Achievement Series-Science Part I and Part II were administered it was decided to analyze the scores statistically to estimate their reliabilities on the basis of item variances. The Kuder-Richardson Formula[1] was used since through empirical study it was found satisfactory even when item difficulties varied considerably as on these tests. It was decided also to make the analyses for Part II on the basis of scores on the 1959 Experimental Edition since it was used for two of the first three years and had more items than the 1958 Experimental Edition.

Two hundred and fifty examinations were selected at random for the analysis of reliability from the 2,601 completed for Part I at the end of the academic year 1957-58. The analysis of reliability for Part II was made with 220 papers selected at random from the 2,312 completed at the end of the academic year 1958-59. Table VI contains the results of the analyses.

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[1] Kuder, G. F. and Richardson, M. W., "The Theory of the Estimation of Tests Reliability." *Psychometrika*, II (1937), 151-60.

An examination of the data in Table VI indicates that the coefficient of reliability computed for Part I is equal to, or greater than, that usually considered satisfactory for tests used for purposes similar to those of this Project. Also the coefficient of reliability for Part II which consisted of "thought-type" items, seemed somewhat higher than might be expected. For these reasons the examination seemed sufficiently reliable.

Table VI
Estimates of Test Reliability Based on Item Variance
(Kuder-Richardson Formula)

SRA Achievement Series-Science	Numbers of Test Items	Numbers of Examinations	Coefficients of Reliability
Part I	109	250	.88
Part II	36	220	.84

The problem of the validities of Part I and Part II was another matter. There were no criterion data available for all the participating schools that might be suitable for estimating validity. Therefore, after consultation with competent persons, the Director decided to use a subjective method. During the visitations to the participating schools, efforts were made by the Director with collaborating judgments, to judge the quality of the science programs and determine how well the scores obtained on Part I and Part II reflected this quality. No effort was made to consider separately the various factors in the programs, such as content or student ability. Rather judgments were made on the basis of a number of general observations. Table VII contains summaries of these observations and also the relevant mean scores from Table I.

In so far as the methods used for estimating test validity are defensible, the evaluations indicate that, disregarding many variables, the test results seem to reflect the quality of the programs. Also they seem to be consistent with the student achievement that might have been expected. It must be emphasized that these are subjective judgments. However with these and other limitations, both stated and implied, it seemed defensible to attribute "face validity" to both Parts I and II of the SRA Achievement Series-Science. Therefore the use of the scores from these examinations for further analyses in Science Motivation Project I was considered justified.

Summary and Conclusions

The data in the preceding tables, as well as the results of the analyses, seem to support these general conclusions:

1. As might be expected, there is great variability among the scores obtained by the students in the participating school systems. Some of the possible sources of this variability will be examined in the later chapters. However, certain relationships that apparently exist between the scores obtained by the students and some of the characteristics of the science programs in the participating schools, seemed fairly consistent from system to system.
2. One "outstanding" observation is the retrograde effect in science achievement that seems to exist from grade 8 to grade 9 in most of the participating systems. In two schools there were decreases between the mean scores obtained from the administration of the tests in 1959 and in 1960. In one case it was noted on Part I and in the other on Part II. In neither, after specific study, could

Table VII

Subjective Evaluations of Participating School Systems

Participating School Systems	Subjective Evaluations	Relevant Mean Scores			
			Grade		
		Part	7th	8th	9th
A	All students took general science in both grades 7 and 8. The program was "somewhat disorganized and spotty" in the 7th grade with some improvement in the 8th although there was little demonstration in either. In the 9th grade there was a marked improvement in the program with much demonstration under a fairly well-trained teacher.	I	39.3	46.0	52.4
		IIS	11.0	12.7	
		IIL		17.7	19.9
B	All students took general science for one semester in each of grades 7 and 8. In the 9th grade about one-half the students elected general science on an optional basis. Teacher demonstration was used in all grades although the quality of overall program was somewhat spotty. In the 9th grade only the "better students" elected science.	I	36.6	43.9	55.9
		IIS	10.5	12.3	
		IIL		17.5	19.4
C	All students elected general science at grades 7, 8 and 9 and were pushed hard. A good sequential program sparked by the head of science department. In general, better-than-average teachers and a better-than-average student body. Much teacher demonstration in all grades with individual experimentation in the 9th grade.	I	44.8	56.3	65.1
		IIS	13.0	14.4	
		IIL		19.9	22.0

Table VII (Continued)

Participating School Systems	Subjective Evaluations	Relevant Mean Scores			
			Grade		
		Part	7th	8th	9th
D	A full year of general science was taught in grades 7, 8 and 9 although the quality of the program in grades 7 and 8 was less than might be desired. In the 9th grade the science teacher was conscientious but had a weak background. Teacher demonstration was used at all grades.	I IIS IIL	38.1 11.2 	44.2 11.8 17.7	54.2 20.5
E	General Science is offered in both grades 7 and 8 with a fairly good teacher who used demonstrations. In the 9th grade science was optional, and only those students who took the course were tested. This group included a number of students who came from another junior high school with a relatively inferior program.	I IIS IIL	38.5 11.8 	50.0 12.5 16.5	49.4 17.5
F	A good general-science program in the 7th grade with a dedicated teacher who used many demonstrations. In the 8th grade four of the five sections of general science required of all students was handled by a teacher who had neither the interest nor the background. The teacher in the 9th grade program was conscientious but the work was fairly repetitious of that in the 8th.	I IIS IIL	46.1 11.2 	48.5 11.5 16.0	58.6 13.4

Table VII (continued)

Participating School Systems	Subjective Evaluations	Relevant Mean Scores			
			Grade		
		Part	7th	8th	9th
G	No science instruction in the 7th grade although general science was taught in the 8th grade to all students by two teachers both of whom were well qualified. However, the study was essentially book oriented with little demonstration. In grade 9 all students had one semester of general science with some demonstration but no individual experimentation. The instructor was less than adequately trained.	I	37.2	48.2	50.0
		IIS	10.8	11.7	
		IIL		16.7	18.8
H	Science was not taught in the 7th grade except incidentally with the social sciences. In the 8th grade the program involved "book study" with a teacher with a less than adequate background. No science in 9th grade.	I	38.3	45.3	50.1
		IIS	11.0	12.0	
		IIL		17.3	18.3
I	All students had general science all three years with the same teacher. The teacher was devoted and conscientious and had sufficient mastery of content to teach 7th and 8th grade science satisfactorily with some doubt about the 9th grade. In general the program in grade 9 was a review of that in grades 7 and 8.	I	45.0	52.8	56.0
		IIS	13.5	14.4	
		IIL		19.5	19.5

Table VII (continued)

Participating School Systems	Subjective Evaluations	Relevant Mean Scores			
			Grade		
		Part	7th	8th	9th
J	No science instruction in the 7th grade although all students took general science in the 8th grade with a good program and a knowledgeable teacher who used demonstrations. Pupils are pushed. In grade 9 the program of general science is relative adequate with a good teacher who uses demonstration and individual experimentation	I	40.0	52.7	61.9
		IIS	12.6	12.6	
		IIL		17.7	20.8
K	A high-quality student body with general science in both grades 7 and 8. Major emphasis however on memorization. In grade 9 all students took biology with emphasis on teacher demonstration.	I	51.2	66.0	66.2
		IIS	15.6	18.6	
		IIL		25.3	24.9
L	No science instruction in 7th grade, although all students elected general science in the 8th grade with a teacher with a weak science background. In the 9th grade science was optional with a choice of biology or general science, the latter being less than optimal. In general the program at all three grades involves book study with little teacher demonstration or individual experimentation.	I	37.9	47.7	50.8
		IIS	8.2	11.1	
		IIL		16.2	17.1

the phenomenon be attributed to faulty test administration.

In only three cases out of a possible 36 is the mean difference between the scores obtained at the 8th and 9th grade, greater than that between those obtained at the 7th and 8th. *In terms of these tests*, science instruction appears to be most effective during the second year of the junior-high-school program. This conclusion seems to apply without regard for the different ranges of scores for the different school systems.

3. In light of the findings thus far, there seems to be ample justification for investigating some of the possible sources of the variability evidenced among the participating schools.

CHAPTER IV

SCIENCE ACHIEVEMENT, THE SRA JUNIOR INVENTORY AND YOUR EDUCATIONAL PLANS

Introduction

One of the questions to which answers were sought in this study dealt with the relationships between science achievement and (a) the adjustment of the student to his environment and (b) the educational image the student had of himself. Some of the answers were sought during the first three years of the study. In order to obtain the data needed, the SRA Junior Inventory: Form A was administered to the student participants during the early fall months of 1957 and 1958, when they were enrolled in the seventh and eighth grades. Your Educational Plans: High School Edition was administered in the fall 1959 when they were in the ninth grade. The scores they obtained on the SRA Junior Inventory were compared with their mental abilities as measured by the SRA Primary Mental Abilities Test, and with their scores on Part I and Part II of the SRA Achievement Series-Science. The results of these analyses are described in the sections that follow.

The SRA Junior Inventory

The SRA Junior Inventory: Form A consists of a series of items grouped in five sections entitled "My Health" (45 items); "Getting Along With Other People" (43 items); "About Me and My School" (44 items); "About Myself" (45 items); and "About Me and My Home" (46 items). These sections will be referred to henceforth in abbreviated form as "Health," "People," "School," "Myself" and "Home." The items are phrased as problems that might bother or worry an adolescent. The student is requested to mark those problems statements that apply to him. The number of items checked indicates the degrees of concern he has in these five areas. Thus a student with a low degree of adjustment in an area will score high in terms of the number of items checked.

The mean numbers of items checked by the students in the participating schools in 1957 and 1958 and the mean I.Q. of the students as measured in 1957 with the SRA Primary Mental Abilities Test appear in Table VIII.

Coefficients of correlation were then computed between the scores the students obtained on the various sections of the Junior Inventory and their I.Q. scores as measured with the Primary Mental Abilities Test. These computations appear in Table IX.

An analysis of the data in Table IX indicates that nearly all the coefficients of correlation are negative, thus showing, in general, that lack of adjustment (greater numbers of problems checked) is positively related to mental ability. Many of the coefficients of correlation are significant at either the .01 or .05 level. However none of them may be considered high in terms of validity for individual prediction.

Lack of adjustment seems to be most highly related to intelligence in the area of school adjustment. These data thus support other research findings that suggest that students of low mental ability generally find the school environment unfavorable. In those schools in which the mean I.Q.'s of the students are highest the negative coefficients of correlation are smaller and in some cases the coefficients of correlation are positive.

Table VIII

Mean Numbers of Items Checked by Students on SRA Junior Inventory in 1957 and 1958

School	Mean I.Q	Health		People		School		Myself		Home	
		1957	1958	1957	1958	1957	1958	1957	1958	1957	1958
A	102.0	4.7	3.3	3.2	2.1	5.2	4.3	5.6	3.9	3.1	2.1
B	98.8	4.9	3.8	3.7	3.1	6.1	5.0	6.3	5.3	3.3	2.3
C	104.0	2.9	2.5	2.2	2.3	3.4	3.2	4.5	4.0	2.0	1.9
D	100.9	3.7	3.0	2.8	2.1	5.0	4.5	5.7	3.9	2.6	1.9
E	98.1	5.7	4.1	3.8	2.6	6.3	4.8	7.1	5.4	4.1	2.8
F	100.0	4.6	2.3	2.6	1.9	6.6	3.3	5.8	3.3	3.3	1.6
G	100.2	4.1	3.5	3.3	2.1	4.7	4.1	5.7	4.2	2.9	2.2
H	106.4	4.7	5.7	4.7	5.0	8.0	7.9	7.6	8.0	4.0	2.7
I	105.4	4.3	3.7	3.8	2.8	4.7	3.8	6.4	4.8	2.6	2.1
J	100.2	3.7	2.4	3.0	2.6	4.5	3.4	4.9	4.0	2.5	1.9
K	110.3	1.8	1.8	1.9	1.4	2.6	1.9	3.3	2.1	1.4	.9
L	110.1	5.1	3.5	4.1	2.7	6.6	4.9	6.4	3.3	3.2	1.4

This suggests that lack of adjustment in the school environment may be an exponential rather than a linear function of mental ability. However even with the highest coefficient of correlation (-.40) the reduction of error in prediction-mental ability vs lack of adjustment-is less than 10%. Hence these coefficients of correlation were not used as "weighting factors" in the next computation.

Table IX

Coefficients of Correlation Between Scores on Junior Inventory and Primary Mental Abilities (1957)

School	Health	People	School	Myself	Home
A	-.24**	-.11	-.33**	-.10	-.14*
B	-.19**	-.22**	-.32**	-.19**	-.24**
C	-.12**	-.16**	-.37**	-.12**	-.16**
D	-.11	-.24*	-.35**	-.14	-.05
E	-.30**	-.21**	-.40**	-.15*	-.22**
F	-.12	-.15	-.15	-.07	-.10
G	-.17**	-.20**	-.21**	-.10*	-.17**
H	-.07	-.01	-.11	.04	-.03
I	.11	.07	-.08	.13	.05
J	-.22**	-.20	-.12	-.07	-.19*
K	.03	-.07	.04	.19	.14
L	-.15	-.14	-.35*	-.08	-.11

*Significant at the 5% level (.05 > P > .01)

**Significant at the 1% level (P < .01)

Adjustment and Science Achievement

Tables X and XI that follow contain the coefficients of correlation computed between the scores that the students obtained in 1957 and 1958 on the SRA Junior Inventory and those they obtained on Part I and Part II of

Table X

Coefficients of Correlation Between Part I Science Scores and Scores Obtained on the SRA Junior Inventory

School	Mean Scores Science-Part I		Health		People		School		Myself		Home	
	1957	1958	1957	1958	1957	1958	1957	1958	1957	1958	1957	1958
A	39.34	45.95	.25**	.21**	.12*	.09	.29**	.24**	.18**	.16**	.20**	.16**
B	36.63	43.88	.15*	.04	.06	.00	.20**	.08	.05	.03	.15*	.13
C	44.84	56.31	.15**	.24**	.03	.15**	.28**	.38**	.14**	.27**	.09**	.21**
D	38.06	44.15	.00	.23*	.11	.01	.21*	.21*	.08	.15	.00	.03
E	38.45	49.96	.20**	.23**	.06	.07	.27**	.29**	.04	.15*	.03	.27**
F	46.05	48.48	.11	.04	.04	.02	.11	.30**	.00	.09	.03	.13
G	37.19	48.24	.20**	.29**	.16**	.20**	.16**	.36**	.13**	.30**	.15**	.23**
H	38.30	45.28	.14	.28**	.20*	.11	.28**	.15	.20*	.12	.20*	.13
I	45.01	52.82	.06	.20*	.08	.08	.22**	.19*	.10	.18	.11	.16
J	40.02	52.65	.17*	.27**	.20*	.18*	.07	.24**	.19*	.19*	.22**	.17*
K	51.20	65.97	.15	.05	.17	.00	.20	.16	.08	.17	.01	.11
L	37.84	47.66	.32*	.20	.15	.20	.24	.44**	.14	.10	.22	.18

*Significant at the 5% level (.05> P> .01)

**Significant at the 1% level (P< .01)

Table XI

Coefficients of Correlation Between Part II Science Scores and Scores Obtained on the SRA Junior Inventory

School	Mean Scores Part II			Health			People			School			Myself			Home		
	1957	1958S	1958L	1957	1958S	1958L	1957	1958S	1959L	1957	1958S	1958L	1957	1958S	1958L	1957	1958S	1958L
A	10.8	13.0	18.1	.11*	.21**	.19**	.09	.10	.11*	.19**	.30**	.34**	.17**	.14**	.11*	.15**	.14**	.16**
B	11.2	12.7	17.9	.01	.04	.00	.12	.05	.00	.20**	.14	.13	.06	.06	.03	.10	.09	.07
C	12.8	14.5	19.9	.08**	.22**	.21**	.10**	.17**	.16**	.20**	.38**	.37**	.15**	.28**	.27**	.13**	.26**	.26**
D	11.3	12.5	17.9	.06	.17	.16	.05	.08	.04	.19*	.19	.22**	.20*	.08	.09	.07	.03	.42**
E	11.8	12.3	16.7	.17**	.25**	.26**	.07	.13	.14*	.27**	.31**	.33**	.13*	.10	.11	.19**	.25**	.25**
F	12.5	11.3	15.9	.00	.16	.07	.11	.02	.01	.01	.23*	.15	.20*	.06	.02	.17	.04	.04
G	10.4	11.8	16.8	.16**	.22**	.22**	.19**	.17**	.18**	.15**	.27**	.28**	.12**	.22**	.21**	.17**	.16**	.16**
H	9.9	12.1	17.3	.03	.11	.10	.01	.10	.11	.04	.15	.22*	.06	.08	.04	.02	.07	.11
I	13.5	14.3	19.6	.03	.18	.16	.05	.31**	.03	.20*	.21*	.20*	.10	.12	.09	.01	.10	.07
J	12.1	12.6	17.9	.26**	.21*	.20*	.29**	.18*	.20*	.21**	.20*	.19*	.27**	.11	.11	.23**	.21*	.20*
K	15.8	18.5	25.3	.03	.12	.05	.05	.12	.08	.18	.12	.12	.01	.13	.20	.18	.08	.16
L	8.2	11.8	16.2	.14	.02	.04	.16	.10	.07	.16	.21	.34*	.05	.02	.02	.10	.16	.17

*Significant at the 5% level ($.05 > P > .01$)

**Significant at the 1% level ($P < .01$)

the SRA Achievement Series: Science.

An examination of Tables X and XI indicates that none of the coefficients of correlation between science achievement and adjustment, despite their confidence levels, are sufficiently high to warrant using factors of adjustment for prediction of success of individuals in science.

In an effort to clarify some of the relationships that might exist among mental ability, adjustment and science achievement, an analysis of the scores used for the computations in Tables X and XI was made on a group basis. In this analysis the mean I.Q.'s, and mean scores for Part I and Part II of the SRA Achievement Series: Science were computed for students who were at or above the 75th percentile and at or below the 25th percentile on the various areas of the SRA Junior Inventory.

Again it should be emphasized that the high percentile ranks indicate lack of adjustment. Table XII that follows contains the results of these computations. Table XIII summarizes the data in Table XII and compares the differences in I.Q.'s, and gains in science achievement made by, the students in the "low adjustment" and "high adjustment" categories between 1957 and 1958.

Tables XII and XIII indicate that the numbers of students evidencing low adjustment in the various areas on the SRA Junior Inventory decreased from 1957 to 1958 the least decrease however being in the area related to school adjustment. They also show an increase in the number evidencing high adjustment over that period as defined by the 25th percentile.

The mean gains in science achievement as well as the differences indicated in mental ability clearly favor the students with high level of adjustment. Thus the "haves" continue to have more and the "have nots" continue to have

Table XII

Mean IQ and Science Scores of Students Evidencing Low and High Degrees of Adjustment*

	Health		People		School		Myself		Home	
	1957	1958	1957	1958	1957	1958	1957	1958	1957	1958
Above 75th Percentile										
N	472.00	288.00	513.00	373.00	390.00	348.00	481.00	321.00	470.00	292.00
IQ	94.38	93.97	94.73	94.82	93.53	90.77	96.09	93.87	96.90	95.02
S1	34.16	40.61	35.93	44.27	34.07	38.18	35.69	42.27	35.19	42.64
S2	10.04	10.62	10.25	11.54	9.79	9.86	10.20	10.83	10.10	10.90
Below 25th Percentile										
N	199.00	341.00	435.00	591.00	651.00	827.00	576.00	825.00	500.00	702.00
IQ	104.02	104.12	102.82	103.08	103.06	104.76	100.88	102.64	100.64	101.32
S1	43.18	52.68	41.76	50.02	42.72	53.21	41.56	50.54	40.95	50.41
S2	12.63	13.90	12.19	13.20	12.27	13.86	11.89	13.24	12.01	13.21

*N = Numbers of students whose scores in the various areas on the SRA Junior Inventory were in the ranges indicated.

IQ = Mean of students included in N as measured in 1957.

S1 = Mean score on Part I of the science test.

S2 = Mean score on Part II of the science test.

Table XIII

Comparison of Mean Differences Between IQ's and Gains in Science Achievement of Low and High Adjustment Students - 1957 and 1958

Criterion	Area of SRA Junior Inventory									
	Health		People		School		Myself		Home	
	Low	High	Low	High	Low	High	Low	High	Low	High
Differences Between Mean IQ's	-.41	.10	.09	.26	-2.76	1.70	-2.22	1.76	-1.88	.68
Gains on Part I	6.45	9.50	8.34	9.26	4.11	10.49	6.58	8.98	7.45	9.46
Gains on Part II	.58	1.37	1.29	1.01	.07	1.39	.63	1.35	.80	1.20

less.

The relationships between mental ability and science achievement evidenced in Table XIII suggest strongly that both achievement in science and a students adjustment are functions of mental ability. The numerous subtle implications that may be postulated are outside the scope of this study and hence will not be dealt with further.

Your Educational Plans

Your Educational Plans consists of two basic elements, one a Booklet of Questions with an Answer Pad that the high-school boy or girl fills out. This element consists in main of thirty-one fixed choice items concerning the various attitudes and intentions the student has toward his future education, and his beliefs about his families views about his future education. Twenty-two of the responses are organized according to the contents of the items, for example, the type of program in which he is enrolled in high school and factual information about his family. The other nine fixed-choice items plus three three response items provide supplementary information.

The second element in the program is a Counselor's Worksheet which summarizes the information contained in the students responses. In this study only information provided by the student is used; the Counselor's Worksheet being disregarded. In analyzing the data from administering Your Educational Plans to the ninth graders, various segments of information provided by the student were compared with the students' achievement in the various science courses beginning at the ninth-grade level. It should be noted that comparisons with achievement scores at the tenth, eleventh and twelfth grades are made with data obtained from administering the YEP at the ninth grade. The discussions that accompany the tables clarify the rationale of the analyses. The first analysis was to compare the various aspirations of the students as indicated by the YEP with their IQ's. Aspirations refer to the types of work the student really expects to be doing after he finishes school and has some job experience.

An examination of the data in Table XIV indicates that 40%, 45%, 70%, 81%, and 85% of the students in the various IQ ranges have aspirations for occupations that now require or are likely to require college training. The likelihood of any of the students in the first two groups successfully completing college is rather remote, assuming that the measurements of mental ability are valid it is unlikely that more than half of the third group (70%) could successfully complete a college program and even this estimate may be highly optimistic. Thus it would seem that the levels of aspiration of many ninth-

Table XIV

Aspirations of Students in Various IQ Ranges

Aspiration Code*	Students in Various IQ Ranges									
	75 and Below		76-92		93-109		110-126		127 and Above	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	4	4%	27	8%	218	27%	199	38%	137	47%
2	36	36%	121	37%	349	43%	226	43%	113	38%
3	11	11%	29	9%	55	7%	18	3%	6	2%
4	40	39%	120	36%	142	17%	55	11%	15	5%
5	6	6%	22	7%	42	5%	21	4%	14	5%
6	4	4%	10	3%	8	1%	7	1%	9	3%
Total	101	100	329	100	814	100	516	100	294	100

*The codes are as follows:
1. Occupations for which a college education is obviously required
2. Occupations for which a college education is increasingly likely to be required
3. Chiefly farming, most of whom will not go to college
4. Working class and service occupations for which college training is not a prerequisite
5. Those who do not have an occupation in mind
6. Girls who are not planning on an occupation for pay

grade students in the less-able groups are inconsistent with their mental abilities. It is not within the scope of this study however to evaluate the desirability of "shooting high." Many of them do however evidence lower aspirations.

Most of the students in the higher IQ ranges do aspire to occupations that demand a high-level of education.

Tables XV, XVI, XVII and XVIII contain comparisons between the aspiration levels of the students as measured in the ninth grade with the scores they

Table XV

Mean Science Scores of Ninth-Grade Students at Various Aspiration Levels

Aspiration Code	Tests: Part I-Science		Part II-Science		Nelson Biology	
	No.	Mean	No.	Mean	No.	Mean
1	530	65.67	524	22.94	87	46.43
2	739	54.71	732	19.70	62	39.14
3	100	55.27	97	18.39	14	35.50
4	317	51.83	303	17.40	42	31.76
5	99	53.38	96	18.93	10	39.40
6	29	55.34	27	20.81	-	-

obtained on various science tests they were administered in the ninth, tenth, eleventh and twelfth grades. In these tables the same Aspiration Code is used as in Table XIV.

Without regard for the factor of intelligence it seems reasonable to assume that the aspiration level of a student bears some relationship to his motivation to profit from an education. It might be assumed that such a positive motivation might influence science achievement.

An analysis of Tables XV-XVIII indicates that at the ninth-grade students who have high occupational aspirations score highest on the science examinations; girls who do not state that they may be gainfully employed scored second; and those who think they will be in the working class and service occupations score lowest. The latter point is consistent with evidence in Table XIV that about half of the lower-ability students do not have high aspirations; and thus the

Table XVI

Mean Science Scores of Tenth-Grade Students at
Various Aspiration Levels

Aspiration Code	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
1	-	-	-	-	336	46.51	20	19.95	2	16.0	1	31	1	25	1	56
2	6	50.00	6	36.83	439	40.97	15	16.80	29	16.31	-	-	-	-	-	-
3	-	-	-	-	44	37.29	2	17.00	5	18.00	-	-	-	-	-	-
4	2	44.00	2	33.50	240	37.32	6	16.50	23	16.17	-	-	-	-	-	-
5	-	-	-	-	42	39.40	3	10.66	4	18.75	-	-	-	-	-	-
6	-	-	-	-	36	43.37	-	-	-	-	-	-	-	-	-	-

Table XVII

Mean Science Scores of Eleventh-Grade Students at Various Aspiration Levels

Aspiration Code	Tests															
	Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry		Dunning Physics		Advanced Biology	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
1	9	42.88	4	35.75	18	60.50	207	22.59	207	21.85	207	44.44	45	36.33	2	16.50
2	14	38.21	17	38.05	35	52.22	134	17.98	132	16.56	132	34.46	18	34.33	-	-
3	3	36.33	-	-	3	62.00	14	19.28	14	17.50	14	36.78	4	36.25	-	-
4	5	42.80	17	40.41	7	51.51	34	18.41	34	17.06	34	35.47	4	35.00	-	-
5	3	34.00	4	38.00	5	53.66	18	23.11	18	20.72	18	43.83	3	41.33	-	-
6	-	-	-	-	-	-	5	23.20	5	23.40	5	46.60	-	-	-	-

Table XVIII

Mean Science Scores of Twelfth-Grade Students at Various Aspiration Levels

Test	Aspiration Code and Mean Scores											
	1		2		3		4		5		6	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Part I-Science	2	36.00	4	42.50	-	-	-	-	-	-	-	-
Part II-Science	2	14.50	4	18.75	-	-	-	-	-	-	-	-
Nelson Biology	3	28.00	7	35.28	-	-	3	33.66	-	-	-	-
Physical Science	2	63.00	2	47.50	-	-	5	59.60	-	-	-	-
Earth Science-Biology	42	61.35	47	57.85	2	61.50	9	55.22	-	-	-	-
Part I-ACS Chemistry	78	16.70	71	13.42	6	11.16	8	19.00	-	-	-	-
Part II-ACS Chemistry	78	16.64	71	12.85	6	11.83	8	16.62	-	-	-	-
Total-ACS Chemistry	78	33.34	71	26.27	6	22.99	8	35.62	-	-	-	-
Dunning Physics	143	45.54	51	40.17	9	45.33	25	44.08	2	39.50	-	-
Advanced Biology	2	16.50	-	-	-	-	-	-	-	-	-	-
Part I-Science and Math	7	28.71	-	-	-	-	-	-	-	-	-	-
Part II-Science and Math	7	13.42	-	-	-	-	-	-	-	-	-	-
Part III-Science and Math	7	34.14	-	-	-	-	-	-	-	-	-	-

abilities of these students are reflected in their science achievement scores at the ninth- and tenth-grade levels.

However, the situations seems to change greatly at the eleventh- and twelfth-grade levels. Among those students with low aspiration levels and low science achievement at the ninth-grade levels, many are apparently among those who score highest on the science achievement test in the eleventh- and twelfth-grades. Many of the low-ability students, of course, do not elect the advanced courses in these grades. However, of those who do, some are among the high achievers. The greatest percentage of high achievers in science at the eleventh- and twelfth-grade levels is without question among those who had high occupational aspirations at the ninth-grade level but they represent less than half of the total group of students who elect science courses. Many of the high achievers are among those who fell in codes 3, 4 and 6 at the ninth-grade level. The wisdom of using occupational aspiration at the ninth-grade level as a device for counseling students into the specialized courses in science in the high school thus cannot be defended. It is interesting to note that the girls at the ninth-grade who do not have plans for being gainfully employed in the future, seldom elect science in the eleventh and twelfth grades. Yet in the ninth and tenth grades they represent the group that scores second highest on the science tests, and in two cases at the eleventh grade level, highest.

Tables XIX, XX, XXI and XXII compare the college plans indicated by the students when they were in the ninth grade with their achievement in the science courses in which they were enrolled in the ninth, tenth, eleventh and twelfth grades. These tables are organized in a manner similar to that in

Table XIX

Comparison Between Science Achievement Scores of Ninth Graders and Their College Plans

College Plans	Tests					
	Part I-Science		Part II-Science		Nelson Biology	
	No.	Mean	No.	Mean	No.	Mean
Definitely will go	391	65.58	389	22.89	67	48.13
Almost sure to go	327	62.45	321	21.63	43	44.32
Very likely to go	183	56.32	177	19.83	18	38.16
Rather likely to go	169	56.89	165	20.23	15	36.40
Unlikely to go	516	52.42	504	18.54	50	33.46
Definitely will not go	220	48.23	217	17.41	22	29.36

Tables XV through XVIII.

The following material is a summation of conclusions about the data in the tables.

At the ninth-grade level science achievement has an extremely high degree of relationship with the hierarchies of college plans professed by the students. Those who express the intention of going to college score highest, and those who indicate definitely they will not go score lowest. There is an almost congruent decline of science achievement with the gradation of college plan between these two extremes.

This same high degree of relationship holds true for the scores on the Nelson Biology Test administered to the tenth graders but not for the other

Table XX

Comparisons Between Science Achievement Scores of Tenth Graders and Their College Plans

College Plans	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Definitely will go	-	-	-	-	225	47.41	21	19.57	2	14.50	7	29.28	7	23.28	7	52.85
Almost sure to go	-	-	-	-	204	45.68	6	20.50	5	16.40	2	36.00	2	31.00	2	67.00
Very likely to go	-	-	-	-	115	41.02	4	20.75	8	15.62	-	-	-	-	-	-
Rather likely to go	4	45.50	4	13.75	107	40.17	5	11.20	2	17.00	-	-	-	-	-	-
Unlikely to go	4	55.00	4	19.50	270	39.10	6	14.16	22	16.86	-	-	-	-	-	-
Definitely will not go	-	-	-	-	93	34.34	4	14.50	23	17.00	-	-	-	-	-	-

Table XXI

Comparisons Between Science Achievement Scores
of Eleventh Graders and Their College Plans

College Plans	Tests															
	Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry		Dunning Physics		Advanced Biology	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Definitely will go	7	42.85	3	37.00	13	64.38	158	22.67	158	21.96	158	44.63	33	38.60	-	-
Almost sure to go	5	41.40	6	38.83	15	56.20	112	22.66	112	21.14	112	43.80	28	33.32	-	-
Very likely to go	-	-	4	37.00	6	56.16	43	18.83	43	18.00	43	37.30	3	37.33	-	-
Rather likely to go	9	42.44	2	25.50	8	52.75	42	16.70	42	15.76	42	32.07	4	40.75	-	-
Unlikely to go	6	37.66	19	41.36	19	51.47	43	15.34	43	13.83	43	29.17	6	29.66	-	-
Definitely will not go	4	36.25	8	40.37	4	47.00	14	16.50	14	15.30	14	31.80	-	-	-	-

Table XXII

Comparisons Between Science Achievement Scores of Twelfth Graders and Their College Plans

Tests	College Plans											
	Definitely will go		Almost sure to go		Very likely to go		Rather likely to go		Unlikely to go		Definitely will not go	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Part I-Science	-	-	-	-	-	-	2	34.50	4	40.00	-	-
Part II-Science	-	-	-	-	-	-	2	14.50	4	17.75	-	-
Nelson Biology	-	-	-	-	2	24.00	-	-	6	38.00	3	31.66
Physical Science	2	55.50	2	52.50	-	-	-	-	2	55.00	3	59.33
Earth Science-Biology	32	62.50	24	61.83	9	61.66	11	57.72	20	54.00	5	44.00
Part I-ACS Chemistry	59	16.44	53	17.07	15	10.53	12	16.81	22	13.42	11	10.63
Part II-ACS Chemistry	59	15.86	53	17.17	15	10.65	12	14.66	22	12.86	11	8.54
Total-ACS Chemistry	59	32.30	53	34.24	15	21.18	12	31.47	22	26.28	11	19.18
Dunning Physics	158	46.18	67	44.32	23	40.95	20	40.85	20	41.35	9	41.44
Advanced Biology	-	-	-	-	-	-	-	-	-	-	-	-
Part I-Science and Math	5	32.24	-	-	-	-	-	-	4	10.50	-	-
Part II-Science and Math	5	14.00	-	-	-	-	-	-	-	-	-	-
Part III-Science and Math	5	39.60	-	-	-	-	-	-	-	-	-	-

tests administered at that level. In fact on the special earth science-biology test used in the tenth grade the relationship was almost inverse. The high degree of positive relationship was again found for most tests administered at the eleventh-grade level, particularly for chemistry and earth science; and at the twelfth-grade level for physics and earth science. The high degree of relationship is not evidenced on the other tests taken by students in these grades.

An interesting conclusion may be drawn from these points. In the "usual" courses offered at each of these grade levels (general science, biology, chemistry and physics respectively) achievement is closely related to the college plans professed at the ninth-grade level. The same holds true for the earth science course which was a "usual" in one school in both the eleventh and twelfth grades.

However, for those students who elect special courses in science, or who elect the usual courses out of the regular pattern, achievement does not seem to have a low degree of relationship with the hierarchy of college plan expressed by the student at the ninth-grade level. This student may achieve considerably higher when he does elect science than the student who has definite intentions at the ninth grade level of attending college.

Thus, as with occupational aspiration, an indication of college plans at the ninth grade level may not be a satisfactory criterion for identifying those who may achieve well in high-school science courses

Tables XXIII, XXIV, XXV and XXVI that follow compares the mean scores the students obtained on the various science examinations with the occupations of their parents.

Table XXIII

Comparisons Between Mean Science Scores of Ninth-Grade Students and Occupational Levels of Parents

Parents Occupational Level	Tests					
	Part I-Science		Part II-Science		Nelson Biology	
	No.	Mean	No.	Mean	No.	Mean
Professional	220	66.30	217	23.79	49	48.46
White Collar	451	61.18	439	21.52	57	40.91
Farming	129	52.04	127	17.67	17	33.70
Working Class and Service	971	54.69	956	19.19	87	37.12

An analysis of the data in Tables XXIII through XXV indicates that with only a few minor exceptions, students whose parents were employed as professionals scored highest on the tests; followed by the "white collar" group; and then the "working class and service" group. With few exceptions students from farming families scored lowest. The differences seem to be greatest at the ninth-grade level and decline somewhat through the twelfth-grade level.

A check of the data concerning the mental abilities of the students fail to indicate the marked disparity shown in achievement. There seems to be two factors to which the disparity in achievement is attributable. Most of the "farming students" began education in one-room or small rural elementary schools in which science programs were practically non-existent. Some of them continued through the seventh and eighth grades in such schools. Also, a further analysis indicates that a disproportionate share of them had the least well-trained science teachers in grades seven and eight. It seems

Table XXIV

Comparisons Between Mean Science Scores of Tenth-Grade Students and Occupational Levels of Parents

Parents Occupational Levels	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Professional	2	50.50	2	13.50	123	48.10	9	21.00	-	-	4	33.50	4	27.25	4	61.75
White Collar	-	-	-	-	269	44.91	12	15.91	8	15.50	6	29.83	6	24.50	6	54.33
Farming	-	-	-	-	60	37.11	2	21.00	3	11.50	-	-	-	-	-	-
Working Class and Service	7	46.28	7	16.28	546	40.07	19	16.89	49	17.00	-	-	-	-	-	-

Table XXV

Comparisons Between Science Scores of Eleventh-Grade Students and Occupational Levels of Parents

Parents Occupational Levels	Tests											
	Nelson Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry		Dunning Pysics		Advanced Biology	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Professional	4	36.50	78	25.67	78	25.26	78	45.93	12	41.91	-	-
White Collar	8	43.87	144	21.03	144	19.23	144	40.26	25	37.60	2	19.00
Farming	4	35.00	24	15.20	24	16.41	24	31.61	8	30.12	-	-
Working Class and Service	17	39.41	163	18.62	163	17.47	163	36.09	30	33.56	-	-

Table XXVI

Comparisons Between Mean Science Scores of Twelfth-Grade Students and Occupational Levels of Parents

Tests	Parents Occupational Level							
	Professional		White Collar		Farming		Working Class and Service	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Part I-Science	-	-	2	[illegible]	-	-	4	[illegible]
Part II-Science	-	-	2	22.50	-	-	4	16.00
Nelson Biology	-	-	3	31.33	2	47.00	7	36.14
Physical Science	4	38.50	7	46.71	-	-	26	37.53
Earth Science-Biology	9	62.33	39	60.17	-	-	52	58.40
Part I-ACS Chemistry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Part II-ACS Chemistry	30	17.53	56	15.01	13	12.08	70	14.25
Total-ACS Chemistry	30	36.31	56	30.61	13	24.00	70	28.93
Dunning Physics	65	46.56	69	44.08	12	41.75	89	42.84
Advanced Biology	-	-	2	19.00	-	-	-	-
Part I-Science and Math	3	29.00	4	31.25	-	-	-	-
Part II-Science and Math	3	15.00	4	12.75	-	-	-	-
Part III-Science and Math	3	34.00	4	36.75	-	-	-	-

defensible to state therefore that the effects of these disadvantages are partly responsible for the low achievement evidenced by this group. There are without doubt other causative factors that are not within the scope of this analysis.

Tables XXVII, XXVIII, XXIX, and XXX contain comparisons of the mean scores obtained by the students on the science tests at the ninth through twelfth grade levels and the levels of education of their parents. These tables follow:

Table XXVII

Comparisons of Mean Science Scores of Ninth-Graders with Parents' Educational Level

Parents Educational Levels	Tests					
	Part I-Science		Part II-Science		Nelson Biology	
	No.	Mean	No.	Mean	No.	Mean
Code 1						
Father	310	66.00	306	23.26	71	46.67
Mother	241	65.66	237	21.75	58	47.37
Code 2						
Father	78	62.85	75	22.52	8	45.75
Mother	87	62.45	86	22.06	17	50.64
Code 3						
Father	68	61.19	66	20.75	7	39.28
Mother	121	65.80	118	22.34	10	44.20
Code 4						
Father	592	59.02	587	20.59	61	37.59
Mother	765	58.09	748	20.51	79	37.97
Code 5						
Father	432	52.75	415	18.86	36	37.61
Mother	402	52.17	394	18.65	29	33.17
Code 6						
Father	284	50.21	271	17.47	25	31.24
Mother	174	49.69	171	16.19	17	29.64

Table XXVIII

Comparisons of Mean Science Scores of Tenth-Graders with Parents' Educational Levels

Parents Educational Level	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1																
Father	2	50.50	2	13.50	176	47.26	17	18.47	2	16.00	3	[illegible]	3	33.50	3	53.80
Mother	2	36.50	2	9.50	129	48.13	21	19.09	2	13.00	3	[illegible]	3	30.60	3	67.20
Code 2																
Father	-	-	-	-	47	42.89	-	-	-	-	-	-	-	-	-	-
Mother	-	-	-	-	57	43.14	3	16.66	-	-	3	[illegible]	3	19.66	3	65.33
Code 3																
Father	-	-	-	-	42	43.23	-	-	2	16.5	-	-	-	-	-	-
Mother	-	-	-	-	80	46.80	-	-	-	-	-	-	-	-	-	-
Code 4																
Father	2	54.50	2	19.00	379	42.65	11	17.36	11	17.00	-	-	-	-	-	-
Mother	6	54.00	6	19.00	455	42.16	14	16.92	21	16.04	-	-	-	-	-	-
Code 5																
Father	4	39.25	4	14.75	222	39.78	9	16.77	17	15.65	3	[illegible]	3	33.00	3	68.66
Mother	2	37.00	2	13.50	218	38.35	4	16.50	17	16.52	-	-	-	-	-	-
Code 6																
Father	3	55.33	3	18.66	127	37.66	3	17.00	24	17.25	-	-	-	-	-	-
Mother	-	-	-	-	72	36.80	2	12.00	16	17.50	-	-	-	-	-	-

Table XXIX

Comparisons of Mean Science Scores of Eleventh-Graders with Parents' Educational Levels

Parents Educational Level	Tests															
	Nelson Biology		Physical Science		Earth Science		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry		Dunning Physics		Advanced Biology	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1																
Father	2	40.50	7	40.42	14	61.00	118	22.63	118	21.65	118	44.28	24	37.12	-	-
Mother	5	42.00	7	36.42	14	61.78	95	24.02	95	22.92	95	46.94	15	37.53	-	-
Code 2																
Father	-	-	-	-	3	53.66	21	25.42	21	23.57	21	49.00	3	33.33	-	-
Mother	-	-	-	-	2	55.50	24	22.36	24	21.50	24	43.86	6	42.83	-	-
Code 3																
Father	-	-	2	31.00	3	54.33	22	22.85	22	20.68	22	43.53	4	39.25	-	-
Mother	2	44.50	4	33.25	6	50.50	46	20.86	46	20.33	46	41.19	5	40.60	-	-
Code 4																
Father	17	41.35	11	39.09	22	52.31	147	19.82	147	18.80	147	38.07	22	34.22	2	5.50
Mother	16	39.00	19	41.00	31	53.90	179	20.17	179	18.90	179	39.07	43	34.34	3	13.66
Code 5																
Father	8	35.00	13	36.07	17	52.23	68	18.07	68	16.92	68	34.99	16	34.50	-	-
Mother	5	40.00	10	41.60	13	53.38	50	16.82	50	14.93	50	31.75	6	31.83	-	-
Code 6																
Father	6	37.83	8	46.87	6	61.83	31	17.93	31	17.40	31	35.33	4	39.00	-	-
Mother	4	36.00	3	36.66	-	-	16	15.06	16	15.93	16	30.99	-	-	-	-

Table XXX

Comparisons of Mean Science Scores of Twelfth-Graders with Parents' Educational Levels

Parents Educational Level	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1																
Father	2	43.00	2	17.00	-	-	-	-	12	60.91	49	17.60	49	16.53	49	34.13
Mother	-	-	-	-	-	-	-	-	13	58.38	32	15.09	32	14.53	32	29.62
Code 2																
Father	-	-	-	-	-	-	-	-	7	64.85	12	14.41	12	14.18	12	28.59
Mother	-	-	-	-	-	-	-	-	7	55.42	16	15.18	16	13.37	16	28.56
Code 3																
Father	-	-	-	-	-	-	-	-	6	62.83	5	17.40	5	12.40	5	29.80
Mother	-	-	-	-	-	-	-	-	10	58.20	20	14.85	20	13.65	20	28.50
Code 4																
Father	4	33.50	4	14.50	4	31.00	4	55.50	47	58.63	56	14.64	56	14.07	56	28.71
Mother	5	35.80	5	15.00	6	31.50	3	55.33	47	63.21	79	15.93	79	15.55	79	31.48
Code 5																
Father	-	-	-	-	3	27.66	3	55.33	23	57.39	33	14.54	33	14.75	33	29.30
Mother	-	-	-	-	4	27.00	5	59.40	20	52.35	18	15.33	18	15.50	18	30.83
Code 6																
Father	-	-	-	-	3	42.66	-	-	5	57.80	9	14.06	9	15.11	9	29.11
Mother	-	-	-	-	2	49.50	-	-	4	55.00	3	9.75	3	10.50	3	20.25

Table XXX (continued)

Comparisons of Mean Science Scores of Twelfth-Graders with Parents' Educational Levels

Parents Educational Level	Tests									
	Dunning Physics		Advanced Biology		Part I-Science and Math		Part II-Science and Math		Part III-Science and Math	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1										
Father	78	44.57	-	-	4	28.00	4	12.50	4	33.25
Mother	63	44.12	-	-	4	27.00	4	11.75	4	29.50
Code 2										
Father	14	46.14	-	-	-	-	-	-	-	-
Mother	13	51.30	-	-	2	29.50	2	16.50	2	42.00
Code 3										
Father	11	49.54	-	-	-	-	-	-	-	-
Mother	32	43.65	-	-	-	-	-	-	-	-
Code 4										
Father	77	44.80	2	5.50	2	35.00	2	15.50	2	42.00
Mother	96	43.85	3	13.66	-	-	-	-	-	-
Code 5										
Father	36	40.41	-	-	2	27.50	2	15.00	2	34.50
Mother	27	43.40	-	-	-	-	-	-	-	-
Code 6										
Father	17	43.94	-	-	-	-	-	-	-	-
Mother	7	42.28	-	-	-	-	-	-	-	-

An examination of the data in Tables XXVII through XXX indicates clearly that the educational levels of the parents identified by Code 1 through Code 6 are closely related to the mean scores the students obtained on the various science tests administered from the ninth through twelfth grades. With only an occasional exception those students whose parents were college graduates scored highest on the examination, and those whose parents had only a grade school education scored lowest. The relationship between the mothers educational level and the students science achievement is greater than that of the father. The students whose mothers were college graduates scored higher than those whose fathers were college graduates. Those whose mothers had only a grade school education scored lower than those whose fathers had only gone to school that far. Thus the level of the mother's education seems to be more highly related to both high and low achievement in science than does the level of the fathers.

Tables XXXI, XXXII, XXXIII and XXXIV contain comparisons between the mean science scores attained by the ninth, tenth, eleventh and twelfth graders and their parents sentiments concerning their continuance in high school and college plans.

An analysis of the data in tables XXXI through XXXIV indicates that science achievement at all grade levels is closely related to the parents sentiments about continued education for their children. Children of those parents who have positive attitudes about their enrollments in college nearly always scored higher on the various science achievement examinations at all levels than the children of those parents who have negative attitudes. The declining hierarchy of positive attitude is accompanied by a decline in

Table XXXI

Comparisons Between Mean Science Scores of Ninth Graders and Parents' Sentiments About Further Education

Parents' Sentiments*	Tests					
	Part I-Science		Part II-Science		Nelson Biology	
	No.	Mean	No.	Mean	No.	Mean
Code 1						
Father	346	64.14	353	22.17	50	47.20
Mother	400	63.48	402	22.21	60	47.18
Code 2						
Father	300	61.62	290	21.86	46	41.65
Mother	300	61.70	290	21.51	42	42.45
Code 3						
Father	815	56.74	794	20.04	82	39.06
Mother	842	55.89	818	19.72	79	37.56
Code 4						
Father	220	48.17	213	16.84	21	32.80
Mother	202	48.06	199	17.23	22	32.59
Code 5						
Father	30	42.23	30	14.06	-	-
Mother	14	43.85	15	13.80	-	-
Code 0	-	-	-	-	-	-

*Codes for Parents' Sentiments:
Code 1 = He (she) thinks college is absolutely necessary for me.
Code 2 = If I did not try to go to college, he (she) would feel I was not only making a mistake, but a serious one.
Code 3 = He (she) would feel I was making a mistake if I did not try to go to college.
Code 4 = He (she) would feel I was making a mistake if I tried to go to college.
Code 5 = He (she) feels I probably ought to quit high school before graduation.
Code 0 = I have no father, stepfather, (mother, stepmother), or equivalent.
The same coding system is also used in Tables XXXII, XXXIII and XXXIV.

Table XXXII

Comparisons Between Mean Science Scores
of Tenth Graders and Parents' Sentiments
About Further Education

Parents' Sentiments	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1																
Father	-	-	-	-	204	46.18	16	20.12	8	16.87	3	31.33	3	25.66	3	56.99
Mother	-	-	-	-	227	46.11	17	18.23	10	17.00	3	40.33	3	36.66	3	76.99
Code 2																
Father	-	-	-	-	172	44.74	10	18.80	2	16.00	6	29.33	6	38.83	6	68.16
Mother	-	-	-	-	180	44.56	11	21.45	3	15.00	4	29.75	4	22.00	4	51.75
Code 3																
Father	5	49.00	5	15.20	493	41.69	13	14.76	21	17.42	3	26.00	3	21.33	3	47.33
Mother	4	51.25	4	15.75	499	41.03	13	14.07	24	16.91	3	26.00	3	21.33	3	47.33
Code 4																
Father	4	55.50	4	20.00	90	34.41	2	12.00	15	16.20	-	-	-	-	-	-
Mother	5	52.40	5	18.60	83	35.54	2	12.00	16	16.81	-	-	-	-	-	-
Code 5																
Father	-	-	-	-	8	24.37	-	-	8	16.00	-	-	-	-	-	-
Mother	-	-	-	-	4	23.00	-	-	3	14.33	-	-	-	-	-	-
Code 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table XXXIII

Comparisons Between Mean Science Scores of Eleventh Graders and Parents' Sentiments About Further Education

Parents' Sentiments	Tests															
	Nelson[1] Biology		Physical Science		Earth Science Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry		Dunning Physics		Advanced Biology	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1																
Father	6	42.33	8	37.12	13	57.53	129	23.32	129	21.95	129	45.27	23	36.26	-	-
Mother	9	41.88	7	36.28	15	56.86	145	22.84	145	21.48	145	44.32	24	37.62	-	-
Code 2																
Father	5	44.40	9	42.55	13	54.30	96	21.92	96	20.58	96	42.50	17	38.76	-	-
Mother	6	42.16	10	41.40	16	55.37	91	22.82	91	21.59	91	44.41	16	39.62	-	-
Code 3																
Father	17	36.88	13	40.46	29	56.48	152	18.66	162	17.80	162	36.46	32	33.90	3	13.66
Mother	14	38.78	17	39.52	28	56.17	161	18.12	161	17.44	161	35.56	33	32.96	3	13.66
Code 4																
Father	3	39.00	10	37.80	8	47.75	12	13.33	12	10.66	12	23.99	-	-	-	-
Mother	3	34.33	7	39.85	6	44.83	10	14.00	10	10.70	10	24.70	-	-	-	-
Code 5																
Father	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mother	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Code 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table XXXIV

Comparisons Between Mean Science Scores of Twelfth Graders and Parents' Sentiments About Further Education

Parents' Sentiments	Tests													
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1														
Father	-	-	-	-	-	-	-	-	24	62.08	47	16.68	47	16.11
Mother	-	-	-	-	-	-	-	-	28	62.75	57	16.33	57	15.25
Code 2														
Father	-	-	-	-	-	-	-	-	19	58.21	44	15.25	44	14.45
Mother	-	-	-	-	-	-	2	60.00	18	57.88	36	15.25	36	15.34
Code 3														
Father	6	40.56	6	17.83	4	30.75	7	55.57	45	60.86	67	15.25	67	14.94
Mother	7	35.28	7	14.85	4	40.75	7	54.14	48	58.52	66	15.66	66	14.85
Code 4														
Father	-	-	-	-	4	29.75	-	-	7	51.42	7	10.00	7	9.83
Mother	-	-	-	-	5	28.80	-	-	7	51.28	8	9.00	8	10.14
Code 5														
Father	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mother	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Code 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table XXXIV (continued)

Comparisons Between Mean Science Scores
of Twelfth Graders and Parents' Sentiments
About Further Education

Parents' Sentiments	Tests											
	Total-ACS Chemistry		Dunning Physics		Advanced Biology		Part I-Science and Math		Part II-Science and Math		Part III-Science and Math	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Code 1												
Father	47	32.79	86	47.98	-	-	-	-	-	-	-	-
Mother	57	31.58	92	46.98	-	-	-	-	-	-	-	-
Code 2												
Father	44	29.70	63	44.01	-	-	5	31.40	5	15.20	5	37.20
Mother	36	30.59	56	44.08	-	-	5	31.40	5	15.20	5	37.20
Code 3												
Father	67	30.19	80	40.67	3	13.66	2	27.50	2	10.00	2	31.50
Mother	66	30.51	83	41.16	3	13.66	2	27.50	2	10.00	2	31.50
Code 4												
Father	7	19.83	4	40.25	-	-	-	-	-	-	-	-
Mother	8	19.14	5	39.00	-	-	-	-	-	-	-	-
Code 5												
Father	-	-	-	-	-	-	-	-	-	-	-	-
Mother	-	-	-	-	-	-	-	-	-	-	-	-
Code 0	-	-	-	-	-	-	-	-	-	-	-	-

science achievement. This conclusion must be considered in the terms of the relationships known to exist between this factor; college attendance on the part of the parent; and mental ability. However, the anomaly between the students occupational aspirations and their mental abilities evidenced in Tables XV through XVIII suggests that there may be a greater degree of realism on the part of the parents.

Tables XXXV, XXXVI, XXXVII and XXXVIII that follow contain comparisons between the mean science scores of the ninth, tenth, eleventh and twelfth graders and their high-school program.

Table XXXV

Comparisons Between Mean Science Scores of Ninth Graders and Their High-School Programs

High School Program	Tests					
	Part I-Science		Part II-Science		Nelson Biology	
	No.	Mean	No.	Mean	No.	Mean
College Preparatory	769	64.57	752	22.63	110	45.70
Commercial Program	252	54.77	247	18.51	28	34.53
General Program	212	48.18	210	18.32	20	34.70
Vocational or Agricultural Program	373	55.71	367	19.70	30	37.00
Some other Program (very different from others)	155	45.80	148	15.92	17	32.58

Table XXXVI

Comparisons Between Mean Science Scores of Tenth Graders and Their High-School Programs

High School Program	Tests															
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
College Preparatory	-	-	-	-	477	46.77	27	19.29	7	15.14	11	30.81	11	25.00	11	55.81
Commercial Program	4	45.75	4	15.25	124	38.71	4	15.25	9	17.88	-	-	-	-	-	-
General Program	-	-	-	-	127	36.18	4	16.50	10	15.50	-	-	-	-	-	-
Vocational or Agricultural Program	3	57.66	3	20.00	210	40.65	7	14.00	13	17.76	-	-	-	-	-	-
Some Other Program (very different from others)	-	-	-	-	56	32.51	2	18.00	18	16.44	-	-	-	-	-	-

Table XXXVII

Comparisons Between Mean Science Scores of Eleventh Graders and Their High-School Programs

High School Program	Tests															
	Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry		Total-ACS Chemistry		Dunning Physics		Advanced Biology	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
College Preparatory	14	43.14	7	40.14	15	60.20	292	21.62	292	20.52	292	42.14	62	36.58	3	13.66
Commercial Program	5	34.20	13	40.53	7	60.42	34	18.60	34	17.08	34	35.68	5	29.80	-	-
General Program	2	34.50	2	33.00	10	50.80	16	13.25	16	13.00	16	26.25	-	-	-	-
Vocational or Agricultural Program	7	42.71	12	37.75	28	53.71	54	20.61	54	19.83	54	40.44	7	35.57	-	-
Some Other Program (very different from others)	3	37.00	7	43.42	4	49.75	6	17.40	6	16.33	6	33.73	-	-	-	-

Table XXXVIII

Comparisons between Mean Science Scores of
Twelfth Graders and Their High School Programs

High School Programs	Tests													
	Part I-Science		Part II-Science		Nelson Biology		Physical Science		Earth Science-Biology		Part I-ACS Chemistry		Part II-ACS Chemistry	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
College Preparatory	2	43.50	2	17.00	-	-	2	55.50	55	63.56	122	16.42	122	15.72
Commercial Program	-	-	-	-	-	-	4	58.75	13	56.92	14	9.71	14	12.5[illegible]
General Program	3	32.00	3	14.66	4	39.25	-	-	10	53.90	8	13.14	8	10.87
Vocational or Agricultural Program	-	-	-	-	3	29.66	3	53.33	16	54.50	20	15.65	20	14.05
Some Other Program (very different from others)	-	-	-	-	-	-	-	-	6	43.50	3	14.33	3	15.50

Table XXXVIII (continued)

Comparisons Between Mean Science Scores of Twelfth Graders and Their High School Programs

High School Programs	Tests											
	Total-ACS Chemistry		Dunning Physics		Advanced Biology		Part I-Science and Math		Part II-Science and Math		Part III Science and Math	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
College Preparatory	122	32.14	169	45.71	3	13.66	8	29.62	8	13.87	8	35.75
Commercial Program	14	22.63	23	40.56	-	-	-	-	-	-	-	-
General Program	8	24.01	9	29.77	-	-	-	-	-	-	-	-
Vocational or Agricultural Program	20	29.70	29	44.32	-	-	-	-	-	-	-	-
Some Other Program (very different from others)	3	29.83	4	37.25	-	-	-	-	-	-	-	-

Tables XXXV through XXXVIII indicate that students enrolled in college preparatory programs consistently score higher on the science tests than do students in other programs. The second highest achievers are those who elect courses in vocational or agricultural programs. This may seem to be a further anomaly since students from farm families consistently score lower than students whose parents are in other occupations. An analysis of this factor is however outside the scope of this study. The lowest achievers in science are students who apparently collect enough credit to graduate but fail to meet the requirements for traditional programs. These findings support certain implications in other tables that students who are goal-directed toward advanced education, either through parental sentiment or by the type of program in which they enrolled in high-school, consistently score higher on science examinations than other students.

In summary the findings from the tables in this chapter are evidence of the relationship between the educational and occupational levels of the parents and the science achievement of the student. Further any type of support a student has for continuing his education seems to be related highly to science achievement. Although it is beyond the scope of the study, it may be assumed that such conclusions would apply to other subject-matter areas as well.

CHAPTER V

THE RELATIONSHIPS AMONG SCIENCE ACHIEVEMENT, MATHEMATICS ACHIEVEMENT AND MENTAL ABILITY

Introduction

An important question to which answers were sought in this study was, "What factors of intelligence are related to subject-matter achievement in the sciences?" As the study developed, additional facets were added to this question, namely (1) the relationship of intelligence to mathematics achievement, and (2) the relationship between achievement in science and achievement in mathematics. For the first three years of the study when the students were in grades 7, 8 and 9 the relationships among the three factors were measured using the results obtained on Parts I and II of the _SRA_ _Achievement_ _Series-Science_, the _SRA_ _Primary_ _Abilities_ _Test_ and the _SRA_ _Achievement_ _Series: Arithmetic_ (Grades 6 to 9). The administration of the latter test was optional and hence data are not available for all schools that participated. However the data that were obtained have been used in evaluating these relationships.

During the last three years of the study the students were in grades 10, 11 and 12 and elected specialized courses in science. The relationships that were measured were confined chiefly to those between mental ability and the scores obtained on the specialized science tests. The results of the analyses appear in the sections that follow.

Relationships between Mental Ability and Science Achievement

The first analyses involved the computation of coefficients of correlation between the scores obtained on the _PMA_ and Parts I and II of the _SRA_ _Achieve-_

ment Series-Science. The results of these analyses appear in Table XXXIX and XL.

An analysis of the data in Table XXXIX indicates that verbal ability in terms of an understanding of the meanings of words, has a greater relationship to science achievement than does any other factor on test that was used. These other factors include space, reasoning, number, word-fluency and IQ. The two factors that seem to have the least relationship were those of number and word-fluency. The coefficients of correlation between word-meaning and science achievement computed for the three years range from a low of .29 to a high of .65. However, seventeen of the thirty coefficients of correlation are .55 or higher. Thus it seems defensible to state that verbal ability is an influential in science achievement in so far as factual information is concerned.

An analysis of the data in Table XL indicates that the relationships found to exist between the scores of Part I of the SRA Achievement Series-Science and the PMA also exist between the scores students obtained on Part II and the PMA. Word-meaning as measured with the PMA has a greater relationship to achievement on Part II that involves the understanding and interpretation of scientific principles, than does any other factor on the PMA. The coefficients of correlation between word-meaning and the scores obtained on Part II range from .25 to .66 whereas those between IQ and the Part II scores range between .07 and .62. The relationships between the reasoning factor on the PMA and the scores on Part II seemed lower than might be expected particularly when the "understanding" and "interpretation" elements of Part II are considered. Eighteen of the forty coefficients of correlation computed with

Table XXXIX

Comparisons Between Scores on PMA and Part I of the SRA Achievement Series-Science

r's

School	Verbal-meaning			Space			Reasoning			Number			Word-Fluency			I.Q.		
	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959	1957	1958	1959
A	.61	.59	.48	.49	.43	.43	.48	.45	.40	.30	.36	.29	.33	.30	.34	.60	.48	.52
B	.45	.41	.49	.19	.27	.40	.19	.24	.41	.11	.12	.22	.24	.20	.21	.30	.30	.43
C	.50	.43	.44	.31	.37	.37	.33	.33	.39	.25	.28	.22	.19	.20	.22	.45	.32	.44
D	.52	.29	.52	.28	.22	.45	.26	.28	.24	.19	.09	.27	.28	.17	.31	.46	.28	.49
E	.66	.65	.61	.45	.42	.29	.45	.49	.46	.31	.30	.27	.39	.37	.47	.61	.55	.48
F	.50	.57	.39	.28	.25	.41	.37	.35	.33	.09	.13	.02	.13	.20	.20	.41	.47	.36
G	.60	.49	.56	.37	.37	.32	.44	.43	.36	.27	.32	.29	.25	.21	.31	.50	.31	.49
H	.56	.52	.35	.33	.35	.31	.27	.21	.21	.10	.02	.09	.24	.17	.27	.39	.26	.35
I	.46	.58	.67	.38	.26	.39	.20	.19	.39	-.14	-.11	.04	.19	.29	.15	.18	.34	.49
J	.40	.60	.55	.25	.47	.48	.26	.49	.44	.12	.17	.27	.41	.31	.45	.39	.44	.58
K	.63	.57	.45	.21	.24	.31	.33	.42	.25	.17	.19	.13	-.09	-.03	.14	.32	.31	.34
L	.57	.58	.61	.24	.45	.39	.19	.41	.54	.05	.02	.15	.24	.22	.49	.42	.27	.45

Table XL

Comparisons Between Scores on PMA and Part II of the SRA Achievement Series-Science

School	Verbal-meaning				Space				Reasoning			
	1957	1958S	1958L	1959	1957	1958S	1958L	1959	1957	1958S	1958L	1959
A	.61	.55	.58	.55	.49	.39	.37	.47	.48	.47	.52	.45
B	.45	.46	.49	.48	.19	.10	.12	.35	.19	.43	.45	.52
C	.50	.42	.49	.42	.31	.20	.24	.28	.33	.32	.38	.36
D	.52	.32	.41	.44	.28	.19	.17	.21	.26	.19	.22	.20
E	.66	.62	.60	.60	.45	.31	.27	.35	.45	.46	.46	.34
F	.50	.50	.30	.25	.28	.11	.01	.16	.37	.34	.29	.06
G	.60	.45	.55	.41	.37	.32	.36	.22	.44	.39	.30	.25
H	.56	.33	.41	.37	.33	.22	.20	.12	.27	.00	.23	.07
I	.57	.50	.49	.44	.24	.20	.20	.15	.19	.31	.34	.26
J	.40	.43	.47	.62	.23	.30	.31	.40	.26	.35	.38	.51
K	.63	.43	.60	.44	.21	.01	.15	.29	.33	.23	.35	.26
L	.46	.47	.55	.31	.38	.48	.51	.18	.20	.41	.35	.19

Table XL (continued)

School	Number				Word-Fluency				I.Q.			
	1957	1958S	1958L	1959	1957	1958S	1958L	1959	1957	1958S	1958L	1959
A	.30	.37	.45	.42	.33	.37	.40	.41	.60	.50	.64	.60
B	.11	.23	.23	.37	.24	.27	.19	.32	.30	.38	.41	.52
C	.25	.30	.31	.27	.19	.17	.20	.20	.45	.29	.47	.43
D	.19	.16	.23	.24	.28	.21	.32	.17	.46	.24	.40	.36
E	.31	.29	.30	.33	.39	.39	.40	.47	.61	.52	.55	.55
F	.09	.16	.03	.12	.13	.16	.14	.09	.61	.31	.22	.17
G	.27	.30	.32	.24	.25	.19	.27	.16	.50	.28	.53	.36
H	.10	-.07	.07	.08	.24	.18	.30	.26	.39	.07	.34	.21
I	.05	.15	.11	.06	.24	.32	.32	.11	.42	.41	.46	.30
J	.12	.25	.31	.33	.41	.27	.31	.56	.39	.35	.49	.62
K	.17	.02	.15	.09	-.09	-.10	-.07	.12	.32	.06	.31	.28
L	.14	.12	-.03	.18	.19	.31	.34	.34	.18	.41	.41	.26

word-meaning had values of .50 or higher whereas only twelve of those between IQ and the Part II scores were .50 or higher. For the space and number factors none were that high.

In summary the evidence suggests that verbal ability, as it involves word-meaning bears a greater relationship to factual knowledge and the understanding of principles of science than the other factors commonly considered to be part of mental ability.

Table XLI lists the coefficients of correlation computed between the scores of Part I and II of the SRA Achievement Series-Science. An examination of the data reveal that in nine out of the twelve schools the coefficients of correlation between the scores obtained on Parts I and II are greater at the ninth-grade level than at the seventh-grade level. Thus one may assume that exposure to science produces greater increments of understanding than of factual achievement since the gains on Part II were proportionally greater than those on Part I. It should be noted that these increases appeared in all the ranges of scores in which the students scores fell. The suggestion that students "topped out" on the test at the ninth-grade level thus artificially increasing the coefficients of correlation, is therefore not tenable. The measure of lower coefficients of correlation between the seventh and ninth grades occurred in schools F, H and K. In school F, as mentioned earlier, the general-science program in the ninth grade was repetitious of that in the eighth. In school H, no science was offered in the ninth grade, and in school K, biology was offered rather than general science. One can conclude therefore that the understanding and interpretation of scientific principles, as measured by the SRA Achievement Series-Science depend on a "maturing" program

Table XLI

Coefficients of Correlation Between Scores on Parts I and II of SRA Achievement Series-Science

School	1957			1958					1959		
	Mean Part I	Mean Part II	r	Mean Part I	Mean Part IIS	r	Mean Part IIL	r	Mean Part I	Mean Part II	r
A	39.3	11.0	.54	46.0	12.7	.62	17.7	.66	52.4	19.9	.64
B	36.6	10.5	.27	43.9	12.3	.62	17.5	.63	55.9	19.4	.64
C	44.8	13.0	.44	56.3	14.4	.59	19.9	.62	65.1	22.0	.66
D	38.1	11.2	.41	44.2	11.8	.41	17.7	.40	54.2	20.5	.69
E	38.5	11.8	.56	50.0	12.5	.72	16.5	.74	49.4	17.5	.78
F	46.1	11.2	.52	48.5	11.5	.43	16.0	.39	58.6	13.4	.38
G	37.2	10.8	.41	48.2	11.7	.71	16.7	.72	50.0	18.8	.42
H	38.3	11.0	.51	45.3	12.0	.50	17.3	.47	50.1	18.3	.28
I	45.0	13.5	.57	52.8	14.4	.65	19.5	.66	56.0	19.5	.67
J	40.0	12.6	.34	52.7	12.6	.69	17.7	.67	61.9	20.8	.79
K	51.2	15.6	.54	66.0	18.6	.65	25.3	.74	66.2	24.9	.33
L	39.9	8.2	.47	47.7	11.1	.58	16.2	.69	50.8	17.1	.58

of general science. In all three schools there was an increase in the mean scores obtained on Part I, but either a decline or a proportionally lower gain on the scores for Part II. Thus, without considering the quality of the science programs in the other nine schools, it seems that continued exposure to experiences in general science is highly related to the students ability to understand and interpret scientific principles.

Relationships between Mental Ability and Arithmetic Achievement

A corollary question to which an answer was sought in this study was the relationship between mental ability and arithmetic achievement, the latter measured with the SRA Achievement Series: Arithmetic (grades 6 to 9). When the study was first undertaken a plan for measuring arithmetic achievement was not included. Consequently the administration of the arithmetic tests project was optional with the schools in the Project. A few requested the privilege of participating. The scores obtained on the arithmetic tests were matched with those obtained on the 1957 and 1959 administrations of the PMA. Computations were not made for the 1958 arithmetic scores since the PMA was not administered that year. Table XLII lists the coefficients of correlation computed between the scores for the years indicated. The numbers 1, 2, 3, 4, 5 and 6 under the headings "Reasoning," "Concepts" and "Computations" in Table XLII refer to the PMA factors of Verbal-meaning, Space, Reasoning, Number, Word-Fluency and IQ respectively.

The data in Table XLII indicate that the relationships between all three areas on the arithmetic test, and Verbal-meaning and IQ on the PMA are similar. The ranges of coefficient of correlation between the Verbal-meaning and

Table XLII

Comparisons Between Scores on PMA and SRA Achievement Series: Arithmetic*

School	Reasoning						Concepts						Computation					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
B																		
1957	.59	.20	.48	.37	.37	.56	.50	.20	.33	.30	.36	.46	.47	.22	.48	.40	.29	.54
1959	.57	.36	.55	.47	.36	.64	.59	.41	.48	.36	.37	.57	.54	.40	.53	.48	.36	.63
C																		
1957	.58	.34	.57	.41	.35	.64	.57	.35	.56	.36	.27	.61	.45	.37	.55	.46	.23	.62
D																		
1957	.60	.12	.50	.43	.35	.57	.53	.38	.52	.26	.39	.63	.57	.13	.47	.45	.38	.60
E																		
1957	.74	.35	.56	.51	.47	.71	.64	.44	.52	.44	.37	.66	.57	.40	.52	.54	.45	.70
F																		
1957	.60	.29	.55	.30	.38	.63	.57	.27	.53	.20	.18	.49	.47	.23	.39	.37	.35	.58
1959	.52	.45	.62	.21	.36	.60	.50	.55	.58	.18	.35	.61	.44	.41	.61	.29	.42	.60
G																		
1957	.62	.42	.60	.48	.45	.70	.62	.44	.59	.46	.44	.68	.51	.39	.55	.49	.39	.64
H																		
1959	.65	.44	.51	.36	.51	.69	.56	.42	.40	.23	.40	.55	.40	.36	.47	.37	.44	.60
I																		
1957	.46	.17	.48	.35	.21	.57	.44	.22	.31	.21	.36	.52	.48	.20	.36	.37	.24	.58
1959	.72	.33	.59	.15	.26	.61	.62	.38	.42	.17	.13	.51	.70	.43	.66	.32	.16	.68
L																		
1957	.60	.40	.48	.37	.37	.64	.38	.55	.43	.23	.25	.53	.53	.51	.57	.48	.49	.78

*See key for code on page 81.

Reasoning, Concepts, and Computation are .46 - .74; .44 - .64; and .40 - .70 respectively. Those between IQ and these three factors are .56 - .71; .46 - .68; and .54 - .78 respectively. It seems therefore that as with the Parts I and Part II on the SRA Achievement Series: Science, verbal ability in terms of understanding of word meaning, has a high relationship with various factors of arithmetic achievement. The similar high degree of relationship found between IQ and arithmetic achievement was not evident between IQ and science achievement. The lower degree of relationship between the Number factor on the PMA and the scores on the arithmetic test was surprising. The data however are not sufficient to warrant any explanations. The significance of verbal ability however in achievement in mathematics cannot be disregarded since these coefficient of correlation are relatively high considering the other variables that are involved.

Relationships between Science Achievement and Arithmetic Achievement

Table XLIII contains coefficients of correlation that were computed between the scores obtained on Parts I and II of the science test and the three sections of the arithmetic test. The numbers of computations are limited since not all schools administered the arithmetic test. The coefficients of correlation indicate generally that the scores obtained on Part I of the science test are most highly related to those on the Reasoning and Concepts sections of the arithmetic test and least with Computation. The scores on Part II of the science test however are more highly related to those on the Concepts section than those on the Reasoning, although the difference is not great. The latter point seem reasonable since Part II of the science test

Table XLIII

Comparisons Between Scores Obtained on SRA Achievement Series: Science and SRA Achievement Series: Arithmetic

School	Science I			Science IIS			Science IIL		
	Reasoning	Concepts	Computation	Reasoning	Concepts	Computation	Reasoning	Concepts	Computation
B									
1957	.56	.43	.27	.36	.26	.34			
1959	.66	.75	.61	.62	.68	.65			
C									
1957	.54	.58	.45	.41	.46	.33			
D									
1957	.46	.55	.41	.43	.51	.41			
E									
1957	.67	.71	.55	.50	.57	.41			
1958	.68	.73	.57	.58	.64	.30	.58	.62	.54
F									
1957	.49	.55	.22	.35	.37	.17			
1958	.62	.61	.44	.44	.35	.30	.40	.32	.27
1959	.58	.71	.40	.34	.33	.34			
G									
1957	.57	.65	.46	.42	.46	.37			
H									
1958	.45	.47	.15	.30	.35	.13	.37	.37	.20
1959	.58	.42	.67	.32	.31	.03			

Table XLIII (continued)

School	Science I			Science IIS			Science IIL		
	Reasoning	Concepts	Computation	Reasoning	Concepts	Computation	Reasoning	Concepts	Computation
I									
1957	.52	.54	.49	.50	.54	.52			
1958	.46	.73	.42	.50	.62	.47	.50	.62	.50
1959	.67	.70	.60	.43	.48	.32			
J									
1958	.69	.81	.62	.59	.64	.59	.60	.64	.59
K									
1958	.53	.57	.50	.51	.59	.44	.56	.63	.49
L									
1957	.60	.61	.44	.38	.29	.44			
1958	.59	.69	.57	.49	.57	.45	.54	.59	.47

deals with the understanding of principles (or concepts) of science.

The data in this section suggest that science achievement is highly related to the ability to reasoning in, conceptual understanding of, mathematics, and not so highly related with computational ability. Implications of these analyses are not directly within the scope of this report.

Relationships Between Mental Ability and Achievement in Specialized Science Courses (1959-60 and 1960-61)

During the last four years of the Science Motivation Project, students elected specialized science courses. Among these elections were the more traditional courses in biology, chemistry and physics. However, in a number of schools courses in earth science, combined courses in earth science and biology, and advanced courses in biology were offered. In this section the relationships between the scores students obtained on the specialized tests during the years 1959-60 and 1960-61 and those they obtained on the SRA Primary Mental Abilities administered in 1959-60 were evaluated. In making these evaluations the Verbal-meaning and IQ scores on the SRA Primary Mental Abilities were used. Tables XLIV and XLV contain the coefficients of correlation that were computed between these scores and those on the specialized science tests. An examination of these tables indicates that with two exceptions, namely for School J on the Nelson Biology Test for 1960-61, and for School A on the combined "Earth Science-Biology Test" the coefficients of correlation between verbal ability and science achievement are higher than those for IQ. Even in these two cases, the differences are only one and three points in the second decimal position respectively. The higher values of the coefficients of correlation for verbal ability may also be noted in

Table XLIV

Comparisons Between PMA Scores (Verbal-meaning) and Science Achievement 1959-60 and 1960-61

School	Science		Nelson Biology		Physical Science	Earth Science-Biology	ACS Chemistry		
	Part I	Part II	1959-60	1960-61			Part I	Part II	Total
A	-	-	-	.64	-	.24	-	-	-
B	.75	.79	.61	.49	-	-	.27	.47	.39
C	-	-	-	.48	-	-	-	-	-
D	-	-	-	.60	-	-	-	-	-
E	-	-	-	.61	-	-	-	-	-
F	-	-	-	.55	-	-	-	-	-
G	-	-	-	.68	-.38	-	-	-	-
H	-	-	.69	-	-	-	-	-	-
I	-	-	-	.47	-	-	-	-	-
J	-	-	-	.67	-	-	-	-	-
K	-	-	.64	-	.85	-	-1	-1	-
L	-	-	.51	.55	.27	-	-	-	-

Table XLV

Comparisons Between PMA Scores (IQ) and
Science Achievement 1959-60 and 1960-61

School	Science		Nelson Biology		Physical Science	Earth Science-Biology	ACS Chemistry		
	Part I	Part II	1959-60	1960-61			Part I	Part II	Total
A	-	-	-	.59	-	.27	-	-	-
B	.43	.51	.55	.32	-	-	.07	.28	.18
C	-	-	-	.42	-	-	-	-	-
D	-	-	-	.39	-	-	-	-	-
E	-	-	-	.50	-	-	-	-	-
F	-	-	-	.48	-	-	-	-	-
G	-	-	-	.55	-.35	-	-	-	-
H	-	-	.44	-	-	-	-	-	-
I	-	-	-	.19	-	-	-	-	-
J	-	-	-	.68	-	-	-	-	-
K	-	-	.38	-	.71	-	-1	-1	-
L	-	-	.11	.41	.23	-	-	-	-

that thirteen of them were .50 or higher and ten were .60 or higher; whereas for IQ only seven were .50 or higher, and two .60 or higher.

It seems reasonable to state therefore that verbal ability has a high degree of relationship with science achievement in the specialized science courses under consideration. This finding is consistent with similar computations between verbal ability and scores obtained on the SRA Achievement Series: Science during the first two years of the Project.

Relationships Between Mental Ability and Achievement in Specialized Science Courses (1961-62 and 1962-63)

During the last two years of Science Motivation Project I (1961-62 and 1962-63) most of the participating students elected specialized science courses although a few enrolled in the ninth-grade general science courses for which the SRA Achievement Series: Science was administered. During their junior years (1960-61) all the participating students were administered the SRA Tests of Educational Ability: Grades 9-12. The later test provides four (4) scores in the areas of "Language," "Reasoning," "Quantitative," and "Total." The coefficients of correlation computed between these four mental ability scores and the scores the students obtained on the science tests in which they enrolled in 1961-62 and 1962-63 are found in Tables XLVI, XLVII, XLVIII, and XLIX. Only those coefficients of correlation that were significant at the 5% level of probability are found in these tables.

An examination of Tables XLVI, XLVII, XLVIII, and XLIX indicates that, in general, the coefficients of correlation between the total scores obtained on the TEA and those on the specialized science achievement tests are higher

Table XLVI

Comparisons Between TEA Scores (Language) and Science Achievement 1961-62 and 1962-63

School	Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry Part I	ACS-Chemistry Part II	ACS-Chemistry Total	Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
A 1961-62	-	-	-	.38	.41	.41	-	-	-	-	-
1962-63	-	-	-	-	-	-	.25	-	-	-	-
B 1961-62	.83	-	-	.31	.51	.42	.34	-	-	-	-
1962-63	-	-	-	-	-	-	.62	-	.55	.31	.19
C 1961-62	-	.44	.62	.29	.30	.31	-	-	-	-	-
1962-63	-	.44	.44	-	-	-	.37	-	-	-	-
D 1961-62	-	-	-	-	-	-	.47	-	-	-	-
1962-63	-	-	-	.56	.37	.51	-	-	-	-	-
E 1961-62	-	.51	-	-	-	-	.54	.71	-	-	-
1962-63	-	-	-	.44	.33	.40	-	.71	-	-	-
F 1961-62	-	-	-	.68	.60	.70	-	-	-	-	-
1962-63	-	-	-	-	-	-	.13	-	-	-	-
G 1961-62	-	-	-	.50	.46	.49	-	-	-	-	-
1962-63	-	-	-	-	-	-	.51	-	-	-	-
H 1961-62	-	-	-	-	-	-	.56	-	-	-	-
1962-63	-	-	-	.48	.49	.56	-	-	-	-	-
I 1961-62	-	-	-	-	-	-	.67	-	-	-	-
1962-63	-	-	-	.40	.46	.44	-	-	-	-	-
J 1961-62	-	-	-	.46	.49	.49	-	-	-	-	-
1962-63	-	-	-	-	-	-	.34	-	-	-	-
K 1961-62	-	.26	-	.51	.70	.65	-	-	-	-	-
1962-63	-	-	-	.36	.29	.43	.53	-	-	-	-
L 1961-62	-	-	-	.45	.49	.48	-	-	-	-	-
1962-63	-	-	-	-	-	-	.58	-	-	-	-

Table XLVII

Comparisons Between TEA Scores (Reasoning) and Science Achievement 1961-62 and 1962-63

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry Part I	ACS-Chemistry Part II	ACS-Chemistry Total	Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
A	1961-62	-	-	-	.18	.35	.30	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.03	-	-	-	-
B	1961-62	.54	-	-	.23	.26	.28	.65	-	-	-	-
	1962-63	-	-	-	-	-	-	.08	-	.38	.59	.76
C	1961-62	-	.28	.36	.19	.21	.22	-	-	-	-	-
	1962-63	-	-.06	.22	-	-	-	.06	-	-	-	-
D	1961-62	-	-	-	-	-	-	.78	-	-	-	-
	1962-63	-	-	-	.33	.10	.24	-	-	-	-	-
E	1961-62	-	.43	-	-	-	-	.42	.18	-	-	-
	1962-63	-	-	-	.32	.30	.34	-	.18	-	-	-
F	1961-62	-	-	-	.46	.70	.45	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.54	-	-	-	-
G	1961-62	-	-	-	.28	.23	.25	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.23	-	-	-	-
H	1961-62	-	-	-	-	-	-	.20	-	-	-	-
	1962-63	-	-	-	.27	.25	.38	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.11	-	-	-	-
	1962-63	-	-	-	.02	.05	.03	-	-	-	-	-
J	1961-62	-	-	-	.41	.43	.43	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.36	-	-	-	-
K	1961-62	-	-	-	.22	.27	.26	-	-	-	-	-
	1962-63	-	-	-	.13	-	.15	.31	-	-	-	-
L	1961-62	-	-	-	.14	.17	.16	-	-	-	-	-
	1962-63	-	-	-	-	-	-	-	-	-	-	-

Table XLVIII

Comparisons Between TEA Scores (Quantitative) and Science Achievement 1961-62 and 1962-63

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry			Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
					Part I	Part II	Total					
A	1961-62	-	-	-	.47	.42	.44	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.37	-	-	-	-
B	1961-62	.46	-	-	.48	.41	.43	.96	-	-	-	-
	1962-63	-	-	-	-	-	-	.50	-	.67	.83	.76
C	1961-62	-	.17	.52	.28	.35	.33	-	-	-	-	-
	1962-63	-	.03	.46	-	-	-	.25	-	-	-	-
D	1961-62	-	-	-	-	-	-	.69	-	-	-	-
	1962-63	-	-	-	.16	.11	.15	-	-	-	-	-
E	1961-62	-	.53	-	-	-	-	.45	.37	-	-	-
	1962-63	-	-	-	.46	.47	.51	-	.37	-	-	-
F	1961-62	-	-	-	.76	.72	.79	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.76	-	-	-	-
G	1961-62	-	-	-	.48	.42	.47	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.43	-	-	-	-
H	1961-62	-	-	-	-	-	-	.67	-	-	-	-
	1962-63	-	-	-	.59	.56	.60	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.37	-	-	-	-
	1962-63	-	-	-	.54	.66	.62	.28	-	-	-	-
J	1961-62	-	-	-	.44	.45	.46	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.54	-	-	-	-
K	1961-62	-	.21	-	.52	.33	.44	-	-	-	-	-
	1962-63	-	-	-	.56	.42	.53	.14	-	-	-	-
L	1961-62	-	-	-	.43	.35	.40	-	-	-	-	-
	1962-63	-	-	-	-	-	-	-.53	-	-	-	-

Table XLIX

Comparisons Between TEA Scores (Total) and Science Achievement 1961-62 and 1962-63

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry Part I	ACS-Chemistry Part II	ACS-Chemistry Total	Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
A	1961-62	-	-	-	.44	.49	.48	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.26	-	-	-	-
B	1961-62	.74	-	-	.42	.53	.50	.85	-	-	-	-
	1962-63	-	-	-	-	-	-	.58	-	.82	.79	.73
C	1961-62	-	.38	.62	.34	.38	.38	-	-	-	-	-
	1962-63	-	.27	.46	-	-	-	.32	-	-	-	-
D	1961-62	-	-	-	-	-	-	.75	-	-	-	-
	1962-63	-	-	-	.59	.33	.51	-	-	-	-	-
E	1961-62	-	-	-	-	-	-	.60	.60	-	-	-
	1962-63	-	.59	-	.52	.46	.52	-	.60	-	-	-
F	1961-62	-	-	-	.69	.72	.70	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.70	-	-	-	-
G	1961-62	-	-	-	.55	.48	.53	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.52	-	-	-	-
H	1961-62	-	-	-	-	-	-	.67	-	-	-	-
	1962-63	-	-	-	.58	.57	.65	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.53	-	-	-	-
	1962-63	-	-	-	.48	.53	.51	-	-	-	-	-
J	1961-62	-	-	-	.54	.57	.57	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.52	-	-	-	-
K	1961-62	-	.21	-	.56	.62	.63	-	-	-	-	-
	1962-63	-	-	-	.49	.36	.52	.48	-	-	-	-
L	1961-62	-	-	-	.44	.45	.45	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.13	-	-	-	-

than those computed for any of the individual sections on the TEA. All the coefficients of correlation computed with the total score are .40 or higher. For the Language score, seventeen of the coefficients of correlation were below .40; for the Reasoning score, 47 were below .40; and for the Quantitative score, nineteen were below .40. Similar computations made with test scores obtained during the first four years of the Project indicated that the relationships between the verbal or language factors of mental ability, as measured by the tests used, were generally higher than for scores obtained with other factors of mental ability, or for the total score.

It was rather surprising to note that, although many of the science tests used were claimed to measure the ability to reason with science subject matter, the coefficients of correlation between the scores obtained on the Reasoning section of the TEA and those obtained on the science achievement tests were the lowest of any computed. It is, of course, difficult to explain this phenomenon with any degree of of validity except to note the general criticism that lip service is paid to the teaching of reasoning in science courses, without any direct effort to accomplish the objectives, and consequently without positive results.

The only test for which the coefficients of correlation were high with scores obtained on analogous sections of the TEA was the Comprehensive Scholarship Examination in Science and Mathematics used at Western Michigan University. The test however was used in only one school and hence the data are too sparse to warrant any general conclusions.

Conclusions

As with data tabulated in earlier chapters of this study, the findings here will be discussed more extensively, with their related implications, in the final chapter. However, one may note that verbal ability at all levels seems to have a high degree of relationship with achievement in science and mathematics in so far as the tests used may be valid. For the last two years, it was noted that the other factors of intelligence as measured by the tests used seemed to bear an increasing relationship to science achievement.

CHAPTER VI

THE RELATIONSHIPS AMONG SCIENCE ACHIEVEMENT, MATHEMATICS ACHIEVEMENT AND READING ABILITY

Introduction

The relationships of various facets of verbal ability, as factors measured in mental ability, to science achievement have already been dealt with in earlier chapters. In this section of the study a direct approach was taken in ascertaining the relationships between reading ability and science achievement, and between reading ability and mathematics achievement. An effort was also made to determine the relationship between IQ and science achievement, holding the factor of reading ability constant.

During the course of the Project reading tests were administered to the participating students in 1958-59 and in 1962-63. The instrument used was the Diagnostic Reading Test: Form A. It was considered defensible to use the scores obtained on the Diagnostic Reading Test, administered early in the school year of 1958, for computing coefficients of correlation with the scores obtained on the science tests administered in both 1957-58 and 1958-59. The "time difference" of administration was unlikely to render the use of the reading scores invalid. It was also considered defensible to use the scores obtained on the reading test in 1962-63 for similar computations for 1961-62 and 1962-63. The computations are described in the sections that follow. Computations were not made for 1959-60 or 1960-61 since reading tests were not administerd during those years.

Relationships Among Science Achievement, Arithmetic Achievement and Reading Ability (1957-58 and 1958-59)

Coefficients of correlation were computed between the five mean scores the participants obtained on the Diagnostic Reading Test, namely, Rate, Story, Vocabulary, Comprehension and Total, with the mean scores obtained on Part I and II of the SRA Achievement Series: Science for 1957 and 1958, and between those obtained in the schools that administered the SRA Achievement Series: Arithmetic. Tables L, LI and LII contain these computations.

In order to reveal more clearly some of the implications of the coefficients of correlation in Tables L and LI, a summary table was prepared. In this Summary Table LIII the numbers of coefficients of correlation falling into various ranges are indicated.

An analysis of the tabulations in Tables L, LI indicates that the facet of reading ability, as measured by the test employed, that has the lowest relationship to science achievement in grades 7 and 8 is Rate. The Story, Vocabulary, Comprehension and Total scores from the Diagnostic Reading Test, in general, all have higher degrees of relationship to science achievement than does the Rate score. This finding applies to scores on both Parts I and II of the science test. With Part I, for 1957 and 1958, only one coefficient of correlation was .50 or higher, and for Part II, none were as high as .50. The numbers of coefficients of correlation computed between Part I and the reading scores having values of .50 or higher for the Story section were 10 and 10 for 1957 and 1958 respectively; for the Vocabulary section, 10 and 11; for the Comprehension section, 11 and 12; and for the Total score,

Table L

Comparisons Between Scores on The Diagnostic Reading Test: Form A and Part I SRA Achievement Series: Science

School	Mean Score Part I	Rate		Story		Vocabulary		Comprehension		Total	
	1958	1957	1958	1957	1958	1957	1958	1957	1958	1957	1958
A	46.642	.48	.52	.63	.54	.70	.68	.71	.67	.74	.71
B	43.936	.29	.31	.60	.59	.55	.58	.60	.63	.61	.64
C	55.244	.28	.29	.50	.55	.53	.58	.55	.64	.61	.68
D	48.013	.41	.36	.51	.60	.63	.70	.34	.41	.59	.67
E	52.568	.32	.29	.59	.44	.68	.70	.60	.65	.69	.73
F	47.862	.27	.23	.57	.59	.44	.48	.52	.63	.55	.61
G	48.736	.17	.32	.55	.66	.53	.72	.58	.69	.59	.75
H	45.506	.20	.04	.56	.55	.57	.51	.61	.63	.64	.62
I	52.871	.39	.36	.52	.60	.66	.60	.58	.65	.67	.67
J	52.677	.24	.33	.44	.70	.47	.74	.43	.74	.47	.77
K	66.160	.11	.12	.49	.44	.67	.61	.49	.46	.64	.60
L	47.612	.18	.27	.72	.69	.60	.70	.76	.79	.71	.78

Table LI

Comparisons Between Scores on The Diagnostic Reading Test: Form A and Part II SRA Achievement Series: Science

School	Mean Score Part II			Rate			Story			Vocabulary			Comprehension			Total		
	1957	1958S	1958L	1957	1958S	1958L	1957	1958S	1958L	1957	1958S	1958L	1957	1958S	1958L	1957	1958S	1958L
A	11.0	12.7	17.7	.31	.43	.27	.41	.50	.53	.45	.60	.57	.45	.60	.59	.47	.63	.61
B	10.5	12.3	17.5	.24	.38	.38	.41	.56	.60	.39	.58	.61	.41	.56	.61	.43	.61	.65
C	13.0	14.4	19.9	.25	.29	.31	.34	.44	.47	.41	.44	.48	.40	.56	.58	.46	.56	.59
D	11.2	11.8	17.7	.31	.37	.39	.41	.34	.45	.48	.50	.54	.22	.17	.22	.43	.43	.48
E	11.8	12.5	16.5	.27	.32	.35	.37	.36	.37	.50	.66	.68	.43	.55	.58	.50	.66	.68
F	11.2	11.5	16.0	.23	.27	.28	.29	.31	.28	.33	.42	.36	.36	.41	.37	.38	.45	.39
G	10.8	11.7	16.7	.13	.26	.48	.33	.53	.50	.35	.55	.64	.39	.58	.62	.39	.60	.67
H	11.0	12.0	17.3	-	.01	.49	.28	.21	.20	.48	.44	.48	.35	.29	.34	.45	.40	.45
I	13.5	14.4	19.5	.42	.34	.41	.52	.47	.52	.55	.57	.62	.56	.51	.58	.59	.58	.65
J	12.6	12.6	17.7	.20	.21	.24	.43	.53	.54	.46	.58	.60	.45	.58	.58	.47	.61	.63
K	15.6	18.6	25.3	.31	.14	.15	.52	.46	.51	.48	.48	.60	.53	.45	.52	.55	.51	.62
L	8.2	11.1	16.2	.11	.21	.33	.37	.38	.41	.34	.41	.46	.25	.48	.55	.32	.46	.53

Table LII

Comparisons Between Scores Obtained on The Diagnostic Reading Test: Form A and SRA Achievement Series: Arithmetic

School	Reasoning					Concepts					Computation				
	Rate	Story	Vocabulary	Comprehension	Total	Rate	Story	Vocabulary	Comprehension	Total	Rate	Story	Vocabulary	Comprehension	Total
B	.41	.52	.68	.58	.68	.39	.55	.71	.62	.71	.27	.47	.61	.54	.62
E	.33	.47	.65	.66	.70	.27	.54	.72	.66	.72	.33	.38	.56	.52	.58
F	.31	.40	.45	.53	.54	.32	.51	.53	.59	.61	.16	.38	.36	.46	.45
H	.03	.39	.45	.47	.50	-.11	.30	.28	.36	.34	-	.22	.20	.24	.23
I	.40	.51	.52	.57	.58	.52	.64	.64	.70	.71	.54	.47	.63	.56	.64
J	.30	.56	.68	.62	.67	.36	.68	.77	.72	.78	.36	.54	.66	.61	.66
K	.13	.44	.61	.52	.63	.26	.41	.60	.45	.58	.15	.25	.49	.33	.46
L	.46	.41	.64	.57	.64	.41	.55	.70	.65	.72	.46	.47	.69	.61	.69

Table LIII

Summary of Coefficients of Correlations
in Tables L and LI in Various Ranges

Ranges of Coefficients of Correlation	Rate					Story					Vocabulary					Comprehension					Total				
	Part I		Part II			Part I		Part II			Part I		Part II			Part I		Part II			Part I		Part II		
	57	58	57	58S	58L	57	58	57	58S	58L	57	58	57	58S	58L	57	58	57	58S	58L	57	58	57	58S	58L
-.01 - .09	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
.10 - .19	3	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
.20 - .29	5	4	5	5	4	-	-	2	1	2	-	-	-	-	-	-	-	2	1	1	-	-	-	-	-
.30 - .39	2	5	3	4	4	-	-	4	4	1	-	-	4	-	1	1	-	3	-	2	-	-	3	-	1
.40 - .49	2	-	1	1	3	2	2	4	3	3	2	1	6	5	3	2	2	5	3	-	1	-	6	4	2
.50 - .59	-	1	-	-	-	7	5	2	4	5	4	3	2	5	2	4	-	2	6	7	3	-	3	3	2
.60 - .69	-	-	-	-	-	2	4	-	-	1	5	3	-	2	6	3	8	-	1	2	6	6	-	5	7
.70 - .79	-	-	-	-	-	1	1	-	-	-	1	5	-	-	-	2	2	-	-	-	2	5	-	-	-

12 and 12. Similar computations for Part II, 1957 score and 1958 "short" and "long" scores indicated that for the Story section 2, 4 and 6 coefficients of correlation exceeded .50 respectively; Vocabulary section 2, 7 and 8; for the Comprehension section 2, 7 and 9; and for the Total score 3, 8 and 9.

One may conclude defensibly therefore, that as measured in this study, facets of reading ability, other than Rate have a high degree of relationship with science achievement. Also, as the student studies more science in grades 7 and 8 the relationship increases, even though the same reading scores are used. Within the limitations of the techniques used for measuring reading ability, it may be concluded that the matrix of reading ability involving comprehension and understanding, have a strong influence on science achievement.

Table LIV that follows summarizes the data for arithmetic in Table LII as Table LIII does for science.

An analysis of the data in summary Table LIV yielded findings similar to those from summary Table LII. Coefficients of correlation were computed for eight schools between scores obtained on the three areas of the arithmetic test and the five scores from the reading test. Of those coefficients of correlation involving the Rate section only two exceeded a value of .50. However, of the three groups of 8 computed between the Story section of the reading test,and the Reasoning, Concepts and Computation areas of the arithmetic test, 3, 6 and 1 exceeded a value of .50 respectively; for the vocabulary section, 6, 7 and 6; for the Comprehension section, 7, 7 and 7; and for the Total score 8, 7 and 7. Thus, as with science achievement the rate factor bears a smaller degree of relationship with the various facets of

Table LIV

Summary of Coefficients of Correlation in Table LII

Ranges of Coefficients of Correlation	Reasoning					Concepts					Computations				
	R*	S	V	C	T	R	S	V	C	T	R	S	V	C	T
-.10 - .00	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
.00 - .09	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
.10 - .19	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-
.20 - .29	-	-	-	-	-	2	-	1	-	-	1	2	1	1	1
.30 - .39	3	1	-	-	-	3	1	-	1	1	2	2	1	1	-
.40 - .49	3	4	2	1	-	1	1	-	1	-	1	3	1	1	2
.50 - .59	-	3	1	5	3	1	4	1	1	1	1	1	1	3	1
.60 - .69	-	-	5	2	4	-	2	2	3	1	-	-	4	2	4
.70 - .79	-	-	-	-	1	-	-	4	2	5	-	-	-	-	-

*The letters R, S, V, C and T refer to the Rate, Story, Vocabulary, Comprehension and Total Scores on the Diagnostic Reading Test: Form A.

arithmetic achievement than do the various matrices of reading ability related to understanding.

Relationships Between Reading Ability and Achievement in Specialized Science Courses (1961-62 and 1962-63)

A further evaluation of the relationships between reading ability and science achievement was made by computing coefficients of correlation between the scores obtained from administering the Diagnostic Reading Test: Form A in

1962-63 and the scores students obtained on the specialized science tests in 1961-62 and 1962-63. Tables LV, LVI, LVII and LVIII that follow contain the computations for the Rate, Story, Vocabulary and Comprehension scores respectively. The Total score was not considered with the specialized science tests.

Summary Table LIX indicates the numbers of coefficients of correlation that fall into various ranges of values.

An analysis of Tables LV through LIX indicates that the relationships between reading ability and achievement on the specialized science tests are similar to those found in the previous sections, between reading ability and achievement on the general science and arithmetic tests. The coefficients of correlation between the scores on the Rate section and those on the specialized science tests were in general lower than those for the other reading ability scores. Only four coefficients of correlation for the Rate section were .50 or above, whereas 14, 21 and 22 were .50 or above for the Story, Vocabulary and Comprehension sections respectively. Also 38 coefficients of correlation for the Rate section were below .10 or negative, whereas only 20, 11 and 8 fell in these ranges for the Story, Vocabulary and Comprehension sections respectively. The data suggest therefore that for many students, achievement in specialized science courses is inversely related to measured reading rate. However, the matrices of reading ability involving understanding seems to have positive influences on achievement in the specialized science areas.

Table LV

Comparisons Between Mean Scores on Diagnostic Reading Test (Rate) and Specialized Science Tests

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry			Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
					Part I	Part II	Total					
A	1961-62	-	-	-	.11	.22	.07	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.11	-	-	-	-
B	1961-62	-	-	-	-	-	-	-.24	-	-	-	-
	1962-63	-	-	-	-	-	-	.14	-	-.04	-.33	-.55
C	1961-62	-	.21	.13	.22	.23	.22	-	-	-	-	-
	1962-63	-	-.67	.10	-	-	-	.33	-	-	-	-
D	1961-62	-	-	-	-	-	-	-.42	-	-	-	-
	1961-62	-	-	-	-.06	.01	-.03	-	-	-	-	-
E	1961-62	-	-.11	-	-	-	-	.01	.54	-	-	-
	1962-63	-	-	-	.07	.08	.09	-	.54	-	-	-
F	1961-62	-	-	-	.27	.75	.30	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.04	-	-	-	-
G	1961-62	-	-	-	.12	.16	.15	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.16	-	-	-	-
H	1961-62	-	-	-	-	-	-	.15	-	-	-	-
	1962-63	-	-	-	.43	.42	.41	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.06	-	-	-	-
	1962-63	-	-	-	-.03	-.11	-.06	-	-	-	-	-
J	1961-62	-	-	-	.48	.49	.50	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.39	-	-	-	-
K	1961-62	-	-.82	-	.17	.40	.31	-	-	-	-	-
	1962-63	-	-	-	-.02	-.04	-.09	.29	-	-	-	-
L	1961-62	.95	-	-	.17	.08	.13	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.52	-	-	-	-

Table LVI

Comparisons Between Mean Scores on Diagnostic Reading Test (Story) and Specialized Science Tests

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry			Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
					Part I	Part II	Total					
A	1961-62	-	-	-	.46	.25	.32	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.41	-	-	-	-
B	1961-62	-	-	-	-	-	-	-.43	-	-	-	-
	1962-63	-	-	-	-	-	-	.35	-	.07	-.30	-.35
C	1961-62	-	.53	.45	.11	.14	.13	-	-	-	-	-
	1962-63	-	-.24	.43	-	-	-	.35	-	-	-	-
D	1961-62	-	-	-	-	-	-	.47	-	-	-	-
	1962-63	-	-	-	.11	.22	.17	-	-	-	-	-
E	1961-62	-	.15	-	-	-	-	.20	.61	-	-	-
	1962-63	-	-	-	.27	.36	.34	-	.61	-	-	-
F	1961-62	-	-	-	.25	-.06	-.02	-	-	-	-	-
	1962-63	-	-	-	-	-	-	-.13	-	-	-	-
G	1961-62	-	-	-	.40	.35	.39	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.44	-	-	-	-
H	1961-62	-	-	-	-	-	-	.46	-	-	-	-
	1962-63	-	-	-	.52	.61	.60	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.49	-	-	-	-
	1962-63	-	-	-	.13	.11	.12	-	-	-	-	-
J	1961-62	-	-	-	.48	.50	.50	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.35	-	-	-	-
K	1961-62	-	-.03	-	.39	.58	.52	-	-	-	-	-
	1962-63	-	-	-	.26	.02	.17	.44	-	-	-	-
L	1961-62	.80	-	-	.60	.59	.61	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.33	-	-	-	-

Table LVII

Comparisons Between Mean Scores on Diagnostic Reading Test (Vocabulary) and Specialized Science Tests

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry			Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
					Part I	Part II	Total					
A	1961-62	-	-	-	-.02	.19	.03	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.08	-	-	-	-
B	1961-62	-	-	-	-	-	-	.42	-	-	-	-
	1962-63	-	-	-	-	-	-	.33	-	.12	.20	.14
C	1961-62	-	.31	.51	.31	.21	.26	-	-	-	-	-
	1962-63	-	-.37	-.48	-	-	-	.33	-	-	-	-
D	1961-62	-	-	-	-	-	-	.38	-	-	-	-
	1962-63	-	-	-	.55	.34	.49	-	-	-	-	-
E	1961-62	-	.52	-	-	-	-	.23	.81	-	-	-
	1962-63	-	-	-	.21	.24	.23	-	.81	-	-	-
F	1961-62	-	-	-	.76	.80	.77	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.89	-	-	-	-
G	1961-62	-	-	-	.35	.33	.35	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.48	-	-	-	-
H	1961-62	-	-	-	-	-	-	.52	-	-	-	-
	1962-63	-	-	-	.47	.55	.52	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.46	-	-	-	-
	1962-63	-	-	-	.48	.40	.45	-	-	-	-	-
J	1961-62	-	-	-	.54	.46	.51	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.23	-	-	-	-
K	1961-62	-	-.69	-	.66	.67	.70	-	-	-	-	-
	1962-63	-	-	-	-.04	.04	.04	.37	-	-	-	-
L	1961-62	.73	-	-	.55	.62	.60	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.20	-	-	-	-

Table LVIII

Comparisons Between Mean Scores on Diagnostic Reading Test (Comprehension) and Specialized Science Tests

School		Nelson Biology	Physical Science	Earth Science-Biology	ACS-Chemistry Part I	ACS-Chemistry Part II	ACS-Chemistry Total	Dunning Physics	Advanced Biology	Part I-Science and Math	Part II-Science and Math	Part III-Science and Math
A	1961-62	-	-	-	.30	.26	.23	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.32	-	-	-	-
B	1961-62	-	-	-	-	-	-	-.12	-	-	-	-
	1962-63	-	-	-	-	-	-	.40	-	.12	-.13	-.20
C	1961-62	-	.54	.53	.22	.20	.21	-	-	-	-	-
	1962-63	-	-.33	.53	-	-	-	.42	-	-	-	-
D	1961-62	-	-	-	-	-	-	.48	-	-	-	-
	1962-63	-	-	-	.30	.30	.32	-	-	-	-	-
E	1961-62	-	.39	-	-	-	-	.26	.73	-	-	-
	1962-63	-	-	-	.29	.37	.35	-	.73	-	-	-
F	1961-62	-	-	-	.63	.39	.41	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.41	-	-	-	-
G	1961-62	-	-	-	.43	.38	.42	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.53	-	-	-	-
H	1961-62	-	-	-	-	-	-	.53	-	-	-	-
	1962-63	-	-	-	.55	.63	.62	-	-	-	-	-
I	1961-62	-	-	-	-	-	-	.58	-	-	-	-
	1962-63	-	-	-	.31	.27	.30	-	-	-	-	-
J	1961-62	-	-	-	.58	.55	.58	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.36	-	-	-	-
K	1961-62	-	-.18	-	.54	.67	.64	-	-	-	-	-
	1962-63	-	-	-	.21	.03	.17	.48	-	-	-	-
L	1961-62	.77	-	-	.64	.66	.66	-	-	-	-	-
	1962-63	-	-	-	-	-	-	.30	-	-	-	-

Table LIX

Summary of Coefficients of Correlation in Tables LV, LVI, LVII and LVIII

Ranges of Coefficients of Correlation	Rate	Story	Vocabulary	Comprehension
-.80 - -.71	1	-	-	-
-.70 - -.61	-	-	-	-
-.60 - -.51	1	-	1	-
-.50 - -.41	1	-	-	-
-.40 - -.31	1	1	1	-
-.30 - -.21	1	2	1	1
-.20 - -.10	3	2	-	3
-.09 - .09	17	5	5	1
.10 - .19	13	10	3	3
.20 - .29	7	6	9	9
.30 - .39	4	10	11	14
.40 - .49	6	11	9	8
.50 - .59	2	7	9	11
.60 - .69	-	6	4	8
.70 - .79	1	-	4	3
.80 - .89	-	1	4	-
.90 - .99	1	-	-	-

Relationships Between Mental Ability and Science Achievement Holding Reading Ability Constant

The high degrees of relationship evidenced between certain factors of reading ability and science achievement at all levels, suggested further analyses of the relationships between mental ability and science achievement, holding the effects of reading ability constant. The computations involved were analyses of covariance. The results of these computations for the SRA Achievement Series: Science for 1957-58, 1958-59 and 1959-60; and for the three major specialized tests administered in 1960-61, 1961-62 and 1962-63 are found in Tables LX, LXI, LXII, LXIII, LXIV, LXV, LXVI, LXVII and LXVIII that follow.

Table LX

Analysis of Covariance Between PMA I.Q. (1957) and Part I Science (1957) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1640	462365.1100		
Within	1617	382753.4100	236.7058	
Difference	23	79611.7000	3461.3782	14.6231

F= 14.6231 is significant at the 1 per cent level

An examination of the analyses of covariance in Tables LX through LXVIII indicates that seven of the ten relationships are significant at the 1% level, and three at the 5% level. The influence of intelligence on science achievement seems to be greater in the generalized courses than in the specialized

Table LXI

Analysis of Covariance Between PMA I.Q. (1957) and Part II Science (1957) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1643	463128.1000		
Within	1566	315973.4300	201.7710	
Difference	77	147154.6700	1911.0996	9.4716

F= 9.4716 is significant at the 1 per cent level

Table LXII

Analysis of Covariance Between PMA I.Q. (1957) and Part I Science (1958) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1504	403716.2800		
Within	1421	272386.5100	191.6864	
Difference	83	131329.7700	1582.2863	8.2545

F= 8.2545 is significant at the 1 per cent level

Table LXIIIa

Analysis of Covariance Between PMA I.Q. (1957) and Part II Science (1958) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1502	403327.6800		
Within	1469	298980.6000	203.5266	
Difference	33	104347.0800	3162.0327	15.5362

F= 15.5362 is significant at the 1 per cent level

Table LXIIIb

Analysis of Covariance Between PMA I.Q. (1957) and Part II Science (1958 Rescored) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1500	401496.1900		
Within	1475	307296.5400	208.3366	
Difference	25	94199.6500	3767.9860	18.0860

F= 18.0860 is significant at the 1 per cent level

Table LXIV

Analysis of Covariance Between PMA I.Q. (1959) and Part I Science (1959) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1374	1172010.9000		
Within	1289	1043373.4000	809.4440	
Difference	85	128637.5000	1513.3823	1.8696

F= 1.8696 is significant at the 1 per cent level

Table LXV

Analysis of Covariance Between PMA I.Q. (1959) and Part II Science (1959) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	1321	1109858.4000		
Within	1286	1034694.5000	804.5835	
Difference	35	75163.9000	2147.5400	2.6691

F= 2.6691 is significant at the 1 per cent level

Table LXVI

Analysis of Covariance Between PMA I.Q. (1959) and Nelson Biology Test (1961) with Total Reading (1958) Held Constant

Source	DF	SS	MS	F
Total	807	132971.0100		
Within	747	119384.1200	159.8180	
Difference	60	13586.8900	226.4481	1.4169

F= 1.4169 is significant at the 5 per cent level

Table LXVII

Analysis of Covariance Between TEA Total (1961) and ACS-NSTA Chemistry Test (1962) with Total Reading (1962) Held Constant

Source	DF	SS	MS	F
Total	440	40111.8820		
Within	352	30453.3050	86.5150	
Difference	88	9658.5770	109.7565	1.2686

F= 1.2686 is significant at the 5 per cent level

Table LXVIII

Analysis of Covariance Between TEA Total (1961) and Dunning Physics Test (1963) with Total Reading (1962) Held Constant

Source	DF	SS	MS	F
Total	307	25138.6500		
Within	257	20546.2160	79.9463	
Difference	50	4592.4340	91.8486	1.1488

F= 1.1488 is significant at the 5 per cent level

courses elected in the later years of high school if the reading factor is held constant. These findings give further support to earlier ones concerning the influences of intelligence and reading ability on science achievement.

CHAPTER VII

RELATIONSHIPS BETWEEN INTEREST AND SCIENCE ACHIEVEMENT

Introduction

During the academic years 1960-61, 1961-62 and 1962-63, the student participants were administered the Kuder Preference Record: Form C. The responses made to the items on the instrument indicate the expressed interests of the students in various areas. The areas are listed below:

Area Number	Area Title
0	Outdoor
1	Mechanical
2	Computational
3	Scientific
4	Persuasive
5	Artistic
6	Literary
7	Musical
8	Social Science
9	Clerical

Various computations and tabulations were then made using the scores students obtained on the various areas, in an effort to identify the relationships that might exist between the expressed interests and science achievement. These efforts and the results are described in the sections that follow.

Relationships Between Individual, and Pairs of, Scores on Kuder Preference Record and Science Achievement

The first analyses were tabulations of the percentages of students in the upper and lower quarters on the various areas of the Kuder according to the "Profile Sheet," whose scores were in the upper and lower quarters on the *Nelson Biology Test* in 1960-61; the *ACS-NSTA Chemistry Test* in 1961-62; and the *Dunning Physics Test* in 1962-63. Tabulations were not made for the other specialized tests, or for scores obtained by students who elected the three tests named above in other years since the numbers of tests involved were small. Tables LXIX, LXX and LXXI contain the results of these tabulations.

Table LXIX

Relationships Between Lowest and Highest *Kuder* Areas and Scores on the *Nelson Biology Test*

Area of Interest	Students in Lower Quarter on *Nelson Biology Test* for 1960-61		Students in Upper Quarter on *Nelson Biology Test* for 1960-61	
	Percent in Lower ¼ on *Kuder* Area	Percent in Upper ¼ on *Kuder* Area	Percent in Lower ¼ on *Kuder* Area	Percent in Upper ¼ on *Kuder* Area
Outdoor	37.4	15.9	28.2	30.4
Mechanical	29.3	16.2	41.0	13.9
Computational	15.2	35.3	17.9	50.1
Scientific	23.8	20.2	6.8	58.9
Persuasive	19.5	28.4	40.1	24.5
Artistic	21.9	25.2	33.9	25.0
Literary	28.1	21.7	26.4	30.7
Musical	46.5	11.2	48.7	13.6
Social Science	19.0	36.2	29.3	35.3
Clerical	12.8	34.3	28.4	27.3

Table LXX

Relationships Between Lowest and Highest *Kuder* Areas and Scores on the *ACS-NSTA Chemistry Test*

Area of Interest	Students in Lower Quarter on *ACS Chemistry Test* for 1961-62		Students in Upper Quarter on *ACS Chemistry Test* for 1961-62	
	Percent in Lower ¼ on *Kuder* Area	Percent in Upper ¼ on *Kuder* Area	Percent in Lower ¼ on *Kuder* Area	Percent in Upper ¼ on *Kuder* Area
Outdoor	41.5	21.0	33.1	24.5
Mechanical	39.1	16.2	33.7	18.5
Computational	16.2	40.3	11.2	61.5
Scientific	7.8	46.9	3.3	76.1
Persuasive	34.3	30.1	41.7	24.5
Artistic	34.3	19.8	37.7	21.8
Literary	30.7	30.7	14.5	49.6
Musical	39.7	15.0	39.0	19.8
Social Science	21.0	35.5	45.0	23.8
Clerical	24.0	30.1	31.7	27.1

An examination of the data in Table LXIX indicates that for the students whose scores fell in the lower quarter on the Nelson Biology Test the two areas in which least interest was expressed were "Outdoor" and "Musical," with 37.4% and 46.5% respectively. The greatest percentages of these students expressed high degrees of interest in "Clerical" (34.3%), "Computational" (35.3%) and "Social Science" (36.2%) areas. For students in the upper quarter

Table LXXI

Relationships Between Lowest and Highest *Kuder* Areas and Scores on the *Dunning Physics Test*

Area of Interest	Students in Lower Quarter on *Dunning Physics Test* for 1962-63		Students in Upper Quarter on *Dunning Physics Test* for 1962-63	
	Percent in Lower ¼ on *Kuder* Area	Percent in Upper ¼ on *Kuder* Area	Percent in Lower ¼ on *Kuder* Area	Percent in Upper ¼ on *Kuder* Area
Outdoor	49.4	12.1	39.1	14.8
Mechanical	58.5	9.0	37.8	9.4
Computational	25.2	51.5	16.2	66.2
Scientific	25.2	35.3	10.8	66.2
Persuasive	43.4	21.2	50.0	18.9
Artistic	39.3	20.2	39.1	16.2
Literary	41.4	30.3	31.0	40.5
Musical	43.4	20.2	41.8	20.2
Social Science	37.3	37.3	39.1	28.3
Clerical	32.3	29.2	40.5	20.2

on the Nelson Biology Test the areas of lowest interest were "Persuasive" (40.1%), "Mechanical" (41.0%) and "Musical" (48.7%). Only 6.8% expressed a low degree of interest in the "Scientific" area. The areas in which high degrees of interest were expressed were "Computational" (50.1%) and Scientific" (58.9%). Thus, at least with those students who are high achievers in Biology, a high degree of interest seems to accompany success.

Similar analyses were then made of the data in Tables LXX and LXXI for students in Chemistry in 1961-62 and in Physics in 1962-63. Of the students whose scores were in the lower quarter on the Chemistry test, the areas in which least interest was expressed were "Mechanical" (39.1%), "Musical" (39.7%) and "Outdoor" (41.5%). Only 7.8% expressed the least interest in the "Scientific" area. These areas of greatest interest for the low achievers in Chemistry were "Computational" (40.3%) and "Scientific" (46.9%). For the students in the upper quarter of achievement in Chemistry the areas of low interest were "Persuasive" (41.7%) and "Social Science" (45.0%). The highest degree of interest of the high achievers in Chemistry was expressed in the "Computational" area (61.5%) and "Scientific" area (76.1%).

For the low achievers in Physics the areas of lowest interest were "Outdoor" (49.4%) and "Mechanical" (58.5%) and the areas of highest interest, "Social Science" (37.3%) and "Computational" (51.5%). For the high achievers in Physics, the areas of lowest interest were "Musical" (41.8%) and "Persuasive" (50.0%) and the areas of high interest "Computational" (66.2%) and "Scientific" (66.2%).

For all three years the low "Outdoor" interest of the low achievers and the low "Persuasive" and "Musical" interests of the high achievers is evident. The high degree of "Scientific" interest however is noted among the low achievers in both Chemistry and Physics. Thus, low level of achievement does not seem to be accompanied with low level of "Scientific" interest in these fields. The high degrees of "Scientific" and "Computational" interests were evident among the high achievers. The data also reveal in general that greater percentages of students have expressed high and low interests the longer they remain in high school. Also the "group interest" in science seems to grow as exposure to the specialized science courses increases.

The next tabulations made were of the distributions of pairs of highest and lowest interest areas on the *Kuder Preference Record* of students who scored in the upper and lower quarters of the science achievement tests. Tables LXXII, LXXIII, LXXIV, LXXV, LXXVI and LXXVII contain these data from the *Nelson Biology Test* administered in 1960-61 for upper and lower groups of students respectively, as well as similar analyses for the *ACS-NSTA Chemistry Test* and *Dunning Physics Test* administered in 1961-62 and 1962-63.

In addition, tabulations appear in Tables LXXVIII, LXXIX, LXXX and LXXXI for students who elected physics during the junior year (1961-62) and chemistry during the senior year (1962-63).

In Tables LXXII through LXXXI, the *Kuder* areas listed in the vertical column at the left, refer to the higher or lower of the two interest areas in the highest or lowest pair. For example, the number 27, heading the "High" column under "Mechanical" means that there were 27 cases in which "Outdoor" and "Mechanical" were the top pair of interest areas with "Outdoor" the higher of the two. The number 132 at the bottom of the "Low" column under "Literary" means that of the 132 pairs of "Musical" and "Literary" the "Musical" areas was the lower of the two.

An analysis of the data in these tables indicates that for the students in the lower quarter on the *Nelson Biology Test* the pairs of areas of lowest interest were Musical-Literary, Literary-Musical and Musical-Artistic. The same pairs of interest areas were among the lowest for the analogous groups

Table LXXII

Numbers of Pairs of Lowest and Highest Kuder Areas for
Students in Lower Quarter on Nelson Biology Test (1960-61)

Kuder Area	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	2	27	-	-	1	5	-	4	-	2	3	-	6	-	-	5	-	9
Mechanical	8	10	-	-	6	-	1	3	-	3	2	2	10	-	13	-	-	2	-	10
Computational	-	-	3	-	-	-	-	-	-	-	-	-	3	-	6	-	-	-	-	-
Scientific	1	3	4	3	1	-	-	-	-	1	-	-	2	-	2	-	-	1	-	7
Persuasive	-	4	-	2	-	-	-	1	-	-	-	-	-	-	1	-	-	3	-	14
Artistic	-	1	1	-	4	-	-	-	-	-	-	-	5	-	4	-	1	-	-	-
Literary	3	-	6	-	12	-	3	-	-	-	5	-	-	-	54	-	1	-	-	-
Musical	9	-	30	-	25	-	7	-	1		34	-	132	-	-	-	6	-	-	-
Social Science	-	6	-	3	-	1	-	8	-	9	-	2	-	1	3	-	-	-	-	52
Clerical	-	19	-	12	-	1	-	13	-	55	-	8	-	-	-	-	-	107	-	-

Table LXXIII

Numbers of Pairs of Lowest and Highest Kuder Areas for
Students in Upper Quarter on Nelson Biology Test (1960-61)

	Kuder Area																			
	Outdoor		Mechan-ical		Compu-tational		Scien-tific		Persua-sive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	1	8	1	-	-	23	-	2	-	3	-	-	-	-	-	10	-	13
Mechanical	6	7	-	-	4	-	-	3	1	-	6	-	4	-	24	-	-	-	1	-
Computational	2	-	3	-	-	-	1	-	1	-	-	-	6	-	18	-	-	-	-	-
Scientific	-	19	1	13	-	1	-	-	-	5	-	1	-	-	-	-	-	7	-	17
Persuasive	-	2	-	1	-	-	-	8	-	-	1	1	-	-	5	-	-	8	-	10
Artistic	2	-	4	-	1	-	-	-	1	-	-	-	11	-	17	-	-	-	-	1
Literary	-	-	8	-	4	-	1	-	4	-	6	-	-	-	36	-	1	-	-	-
Musical	7	-	24	-	16	-	2	-	8	-	30	-	71	-	-	-	19	-	-	-
Social Science	-	6	-	-	-	-	-	18	-	18	-	-	1	-	-	-	-	-	-	41
Clerical	-	12	-	4	-	3	-	29	-	18	-	5	-	-	-	-	-	34	-	-

Table LXXIV

Number of Pairs of Lowest and Highest Kuder Areas for Students in Lower Quarter on ACS-NSTA Chemistry Test (1961-62)

	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	2	7	-	-	-	10	-	1	-	-	1	-	-	-	-	3	-	3
Mechanical	2	5	-	-	2	-	1	2	-	2	1	1	3	-	5	-	-	-	1	1
Computational	-	-	4	-	-	-	-	-	1	-	2	-	2	-	3	-	-	-	-	-
Scientific	-	7	-	2	-	-	-	-	-	2	-	-	-	-	-	-	-	3	-	1
Persuasive	-	-	-	2	-	-	-	2	-	-	1	-	-	-	1	-	-	2	-	12
Artistic	2	-	1	-	1	-	-	-	1	-	-	-	4	-	8	-	-	-	-	2
Literary	1	-	2	-	4	-	-	-	-	-	5	-	-	-	21	-	1	2	-	-
Musical	9	-	13	-	7	-	-	-	1	-	18	-	33	-	-	-	1	-	-	-
Social Science	1	9	-	1	-	-	-	7	-	6	-	1	-	-	-	-	-	-	-	17
Clerical	-	5	-	5	-	3	-	11	-	15	-	1	-	-	-	-	-	13	-	-

Table LXXV

Number of Pairs of Lowest and Highest *Kuder* Areas for Students in Upper Quarter on *ACS-NSTA* *Chemistry* *Test* (1961-62)

	Kuder Area																			
	Outdoor		Mechan-ical		Compu-tational		Scien-tific		Persua-sive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	2	-	-	-	9	-	1	1	-	-	-	1	-	-	3	-	2
Mechanical	1	-	-	-	3	-	-	5	-	-	-	-	-	-	6	-	-	1	-	1
Computational	1	-	1	-	-	-	-	-	-	-	-	-	-	-	5	-	1	-	-	-
Scientific	-	22	-	6	-	-	-	-	-	6	-	1	-	-	-	-	-	8	-	15
Persuasive	-	-	-	1	-	-	-	4	-	-	-	1	1	-	6	-	-	3	-	3
Artistic	1	-	-	-	-	-	-	-	2	-	-	-	5	-	7	-	2	-	1	-
Literary	-	-	1	-	-	-	-	-	-	1	4	-	-	-	16	-	1	-	-	-
Musical	3	-	4	-	7	-	-	-	4	-	28	-	21	-	-	-	12	-	-	-
Social Science	-	8	-	-	-	-	-	8	-	2	-	1	3	-	1	-	-	-	-	2
Clerical	-	1	-	6	1	3	-	16	-	4	-	1	-	-	-	-	-	4	-	-

Table LXXVI

Numbers of Pairs of Lowest and Highest *Kuder* Areas for Students in Lower Quarter on *Dunning Physics Test* (1962-63)

	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	1	-	-	-	7	-	1	-	-	-	-	-	-	-	3	-	3
Mechanical	2	1	-	-	-	-	-	1	-	-	-	1	-	-	5	-	-	-	-	1
Computational	-	-	-	-	-	-	1	-	1	-	-	-	1	-	1	-	-	-	1	1
Scientific	-	6	-	4	-	-	-	-	-	4	-	-	-	-	1	-	-	1	-	2
Persuasive	-	1	-	1	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	6
Artistic	-	1	2	-	-	-	-	-	-	-	-	-	2	-	4	-	-	-	-	-
Literary	-	-	1	-	-	-	-	-	-	-	2	-	-	-	15	-	1	-	-	-
Musical	-	-	4	-	4	-	-	-	-	-	8	-	24	-	-	-	1	-	-	-
Social Science	-	5	-	2	-	-	-	6	-	3	-	-	2	-	1	-	-	-	-	6
Clerical	-	1	-	3	-	1	-	4	-	3	-	2	-	-	-	-	-	4	-	-

Table LXXVII

Number of Pairs of Lowest and Highest Kuder Areas for Students in Upper Quarter on Dunning Physics Test (1962-63)

	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	3	-	-	-	9	-	-	-	-	-	-	-	-	-	2	-	1
Mechanical	1	1	-	-	-	-	-	3	-	-	-	1	-	-	-	-	-	-	-	-
Computational	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-
Scientific	-	13	-	3	-	-	-	-	-	2	-	-	-	-	-	-	-	3	-	7
Persuasive	-	-	-	1	-	-	-	1	-	-	-	-	1	-	2	-	-	1	-	-
Artistic	1	-	-	-	1	-	-	-	1	1	-	-	-	-	5	-	2	-	-	-
Literary	-	-	-	-	1	-	-	-	1	-	3	-	-	-	8	-	-	-	-	-
Musical	-	-	1	-	1	-	-	-	5	-	7	-	19	-	-	-	1	-	1	-
Social Science	-	3	-	-	-	-	-	3	-	1	-	-	-	-	7	-	-	-	-	-
Clerical	-	-	-	2	-	1	-	4	-	1	-	1	-	-	-	-	-	1	-	-

Table LXXVIII

Numbers of Pairs of Lowest and Highest Kuder Areas for
Students in Lower Quarter on Dunning Physics Test (1961-62)

Kuder Area	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	2	-	-	-	4	-	-	-	-	-	-	1	-	-	2	-	-
Mechanical	1	-	-	-	-	-	-	1	-	-	-	-	1	-	2	-	-	-	-	-
Computational	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Scientific	-	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
Persuasive	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
Artistic	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Literary	-	-	1	-	1	-	1	-	1	-	1	-	-	-	2	-	-	-	-	-
Musical	2	-	3	-	2	-	-	-	-	-	9	-	8	-	-	-	2	-	-	-
Social Science	-	-	1	2	-	-	-	4	-	1	-	-	-	-	-	-	-	-	-	3
Clerical	-	-	-	-	-	2	-	2	-	5	-	-	-	-	-	-	-	3	-	-

Table LXXIX

Numbers of Pairs of Lowest and Highest Kuder Areas for Students in Upper Quarter on Dunning Physics Test (1961-62)

	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Mechanical	-	1	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-
Computational	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scientific	-	-	-	-	-	2	-	-	-	3	-	1	-	-	-	-	-	2	-	5
Persuasive	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Artistic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Literary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	-	-	-
Musical	2	-	-	-	2	-	-	-	-	-	7	-	6	-	-	-	3	-	-	-
Social Science	-	-	-	-	-	-	-	2	-	-	-	-	-	-	3	-	-	-	-	1
Clerical	-	1	-	2	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-

Table LXX[illegible]

Number of Pairs of Lowest and Highest Kuder Areas for
Students in Lower Quarter on ACS-NSTA Chemistry Test (1962-63)

	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	5	-	-	-	6	-	1	-	-	1	-	-	-	-	3	-	-
Mechanical	1	-	-	-	1	-	-	1	-	-	1	-	1	-	3	-	-	-	-	-
Computational	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Scientific	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2
Persuasive	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	6
Artistic	-	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Literary	1	-	4	-	4	-	-	-	-	-	1	-	-	-	9	-	-	-	-	-
Musical	4	-	4	-	9	-	-	-	-	-	10	-	15	-	-	-	1	-	1	-
Social Science	-	4	-	2	-	-	-	3	-	3	-	1	-	-	-	-	-	-	-	14
Clerical	-	-	-	-	-	-	-	2	-	7	-	-	-	-	-	-	-	9	-	-

Table LXXXI

Number of Pairs of Lowest and Highest Kuder Areas for Students in Upper Quarter on ACS-NSTA Chemistry Test (1962-63)

	Kuder Area																			
	Outdoor		Mechanical		Computational		Scientific		Persuasive		Artistic		Literary		Musical		Social Science		Clerical	
Kuder Area	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Outdoor	-	-	-	-	-	-	-	10	-	-	1	1	-	-	-	-	-	1	-	2
Mechanical	1	2	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	1
Computational	-	-	1	-	-	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-
Scientific	-	6	-	4	-	-	-	-	-	1	-	-	-	-	-	-	-	6	-	6
Persuasive	-	-	-	-	1	-	-	-	-	-	1	2	1	-	1	-	-	1	-	1
Artistic	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Literary	-	-	1	-	2	-	-	-	-	-	1	-	-	-	9	-	-	-	-	-
Musical	-	-	2	-	-	-	-	-	4	-	9	-	18	-	-	-	4	-	-	-
Social Science	-	4	-	-	1	-	-	4	-	-	-	1	-	-	3	-	-	-	-	4
Clerical	-	-	-	2	-	1	-	5	-	1	-	-	-	-	-	-	-	2	-	-

of students in Chemistry in 1961-62 and 1962-63; and also for the analogous groups of students in Physics in these same years. Surprisingly, this same conclusion applies to the students whose scores fell in the upper quarter on these same tests. One may conclude that students who elect the more specialized science courses, without regard for their levels do not have high relative degrees of interest in the cultural fields.

For students in the lowest quarter of achievement in Biology, the highest pairs of interest areas were Clerical-Social Science, Social Science-Clerical, Clerical-Persuasive and Outdoor-Mechanical. This is generally true also for students in the lowest quarter of achievement on the Chemistry and Physics Tests. Thus for the low achievers in the specialized sciences, the highest pairs of interest areas are oriented toward the services and sales fields. For the highest achievers in Biology the highest pairs of interest areas were Social Science-Clerical, Clerical-Social Science, with Outdoor-Scientific, Scientific-Outdoor and Clerical-Scientific following. For the high achievers in Chemistry the highest pairs were Outdoor-Scientific, Clerical-Scientific and Scientific-Clerical. The same applies in terms of pairs of interest areas for the high achievers in Physics. One may reasonably state that the usual stereotypes of pairs of interests of high achievers in science, focussed around Scientific, Mechanical and Computational areas is not evidenced in this study. The Scientific area of interest did appear more frequently in the pairs as students elected more specialized courses in science. However, the "usually-expected" combinations of interest areas in the pairs did not become "fixed."

CHAPTER VIII

THE RELATIONSHIPS BETWEEN TEACHER CHARACTERISTICS AND RELATED FACTORS, AND SCIENCE ACHIEVEMENT

Introduction

Two of the more important questions investigated in this Project appear on page 9 of this report, and read as follows:

> "3. To what extent does the subject-matter training of the junior-high-school teacher influence students to elect courses in science in high school in the area in which the junior-high teacher is best trained?
>
> 4. What factors in the personality of the teacher of science seem to motivate students to elect courses in sciences in high school?"

The data for answering these questions were obtained in two ways. The transcripts of the science teachers who were participants in the study were analyzed at the end of each school year. Data concerning the various courses they had elected at the undergraduate and graduate levels in science and mathematics were abstracted from these transcripts. This activity was undertaken in the offices of the participating schools and up-to-date transcripts were obtained as needed. The courses were tabulated by title, the number of semester hours awarded for satisfactory completion of each, and the years in which they were taken. Data concerning the personality characteristics of the teachers were obtained by administering the Personal Audit to all science teachers who taught the participating students during the first three years of the Project. It was not feasible to obtain similar data for the teachers of specialized science during the last three years of the study.

The information gathered in the manner indicated was used in the analyses in the following sections.

Relationships Between Science Achievement and the Science Teachers Undergraduate Science Training

From the tabulations emerging from the analysis of the transcripts of the science teachers who were involved in the Project data were abstracted concerning the number of semester hours of undergraduate science courses that the teachers had completed satisfactorily. Where teachers had elected courses on the term-hour basis, the numbers of hours were converted to semester hours. Analyses of covariance were then computed between the number of undergraduate hours that the teachers had earned and the scores the students had received on the various science tests holding IQ constant. Tables LXXXII, LXXXIII, LXXXIV, LXXXV, LXXXVI, LXXXVII, LXXXVIII, LXXXIX and XC contain the results of these computations.

Table LXXXII

Analysis of Covariance Between Teachers Undergraduate Hours and Part I Science (1957) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1230	788933.8400		
Within	1157	735844.4000	635.9934	
Difference	73	53089.4400	727.2526	1.1434

F= 1.1434 There is no significant difference

Table LXXXIII

Analysis of Covariance Between Teachers Undergraduate Hours and Part II Science (1957) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1244	793043.0000		
Within	1218	770128.8600	632.2897	
Difference	26	22914.1400	881.3130	1.3938

F= 1.3938 There is no significant difference

Table LXXXIV

Analysis of Covariance Between Teachers Undergraduate Hours and Part I Science (1958) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1658	590346.3300		
Within	1574	558735.2900	354.9906	
Difference	84	31591.0400	376.0838	1.0594

F= 1.0594 There is no significant difference

Table LXXXV

Analysis of Covariance Between Teachers Undergraduate Hours and Part II Science (1958) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1687	596330.1300		
Within	1660	583039.0600	351.2283	
Difference	27	13291.0700	492.2618	1.4015

F= 1.4015 There is no significant difference

Table LXXXVI

Analysis of Covariance Between Teachers Undergraduate Hours and Part I Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1264	377301.5600		
Within	1182	351208.5900	297.1307	
Difference	82	26092.9700	318.2069	1.0709

F= 1.0709 There is no significant difference

Table LXXXVII

Analysis of Covariance Between Teachers Undergraduate Hours and Part II Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1345	493745.8700		
Within	1306	483566.9900	321.0936	
Difference	39	10178.8800	260.9969	.8128

F= .8128 There is no significant difference

Table LXXXVIII

Analysis of Covariance Between Teachers Undergraduate Hours and Scores in Specialized Science Courses (1960) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1105	487926.6100		
Within	1040	448759.4200	431.4994	
Difference	65	39167.1900	602.5721	1.3964

F= 1.3964 is significant at the 5% level

Table LXXXIX

Analysis of Covariance Between Teachers Undergraduate Hours and Scores in Specialized Science Courses (1961) with *PMA* I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	585	2240284.6000		
Within	497	1896892.7000	3816.6855	
Difference	88	343391.9000	3902.1806	1.0224

F= 1.0224 There is no significant difference

Table XC

Analysis of Covariance Between Teachers Undergraduate Hours and Scores in Specialized Science Courses (1962) with *TEA* Total (1961) Held Constant

Source	DF	SS	MS	F
Total	43	1024.7525		
Within	18	373.7049	20.7613	
Difference	25	651.0476	26.0419	1.2543

F= 1.2543 There is no significant difference

Any implications drawn from Tables LXXXII through XC must be made with certain limitations. Although the analyses of covariance were computed between the teachers *undergraduate* hours in science and the scores their students obtained on the science tests, it was not possible to eliminate the effect of any graduate study in science these teachers may have had from the analyses. Obvious the graduate study is likely to have affected their teaching even if it was not considered in the computations. Nevertheless it was hoped to obtain some evidence about the influence of the base of the undergraduate hours on the science achievement of the students.

With these limitations in mind, the computations indicate, that except for one case, there is no significant difference between the number of undergraduate hours elected by the teachers and the scores their students obtained on the science examinations, when intelligence was held constant. The only exception is with the specialized courses the students elected in 1960-61, where the difference was significant at the 5% level. However, this difference was based on a variety of specialized courses which the students elected, although most of the elections were in Biology. Consequently there is doubt about the meaningfulness of the difference. One may conclude therefore that the number of undergraduate hours of science elected by the teacher do not seem to be closely related to the achievement of their students in science courses.

Relationships Between Science Achievement and the Science Teachers Graduate Science Training

Tables XCI, XCII, XCIII, XCIV, XCV, XCVI, XCVII, XCVIII and XCIX contain the results of computations analogous to those in Tables LXXXII through XC except the number of semester hours of graduate science training the teachers had completed satisfactory was considered. The results of the computations of the analyses of covariance follow.

Table XCI

Analysis of Covariance Between Teachers Graduate Hours and Part I Science (1957) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1230	423897.6100		
Within	1157	393743.1500	340.3138	
Difference	73	30154.4600	413.0747	1.2138

F= 1.2138 There is no significant difference

Table XCII

Analysis of Covariance Between Teachers Graduate Hours and Part II Science (1957) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	533	541625.3100		
Within	508	509992.4000	1003.9220	
Difference	25	31632.9100	1265.3164	1.2603

F= 1.2603 There is no significant difference

Table XCIII

Analysis of Covariance Between Teachers Graduate Hours and Part I Science (1958) with PMA I.Q. (1958) Held Constant

Source	DF	SS	MS	F
Total	1658	282561.9600		
Within	1574	263282.4600	167.2696	
Difference	84	19279.5000	229.5178	1.3721

F= 1.3721 is significant at the 1% level

Table XCIV

Analysis of Covariance Between Teachers Graduate Hours and Part II Science (1958) with PMA I.Q. (1958) Held Constant

Source	DF	SS	MS	F
Total	733	457563.6700		
Within	726	433346.6000	596.8961	
Difference	27	24217.0700	896.9285	1.5026

F= 1.5026 There is no significant difference

Table XCV

Analysis of Covariance Between Teachers Graduate Hours and Part I Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1264	244521.3000		
Within	1182	223626.5300	189.1933	
Difference	82	20894.7700	254.8142	1.3468

F= 1.3468 is significant at the 1% level

Table XCVI

Analysis of Covariance Between Teachers Graduate Hours and Part II Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1545	551942.8000		
Within	1506	528662.8900	351.0377	
Difference	39	23279.9100	596.9207	1.7004

F= 1.7004 is significant at the 5% level

Table XCVII

Analysis of Covariance Between Teachers Graduate Hours and Scores in Specialized Science Courses (1960) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	683	488519.6200		
Within	620	400178.5400	645.4492	
Difference	63	88341.0800	1402.2393	2.1725

F= 2.1725 is significant at the 5% level

Table XCVIII

Analysis of Covariance Between Teachers Graduate Hours and Scores in Specialized Science Courses (1961) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	501	293042.1000		
Within	416	242696.5800	583.4052	
Difference	85	50345.5200	592.3002	1.0152

F= 1.0152 There is no significant difference

Table XCIX

Analysis of Covariance Between Teachers Graduate Hours and Scores in Specialized Science Courses (1962) with TEA Total (1961) Held Constant

Source	DF	SS	MS	F
Total	43	191.0160		
Within	18	49.9578	2.7754	
Difference	25	141.0582	5.6423	2.0329

F= 2.0329 There is no significant difference

The implications from Tables XCI through XCIX must be viewed with limitations similar to those from Table LXXXIII through XC. Although only the graduate science training of the teachers was considered in the computations it was not possible to eliminate the possible influences of the undergraduate science courses they had elected. Nevertheless it was hoped to ascertain what relationship might exist between these graduate hours and the success of their students.

An examination of Tables XCI through XCIX indicate that four of the nine analyses of covariance are significant. Two of these involving Part I of the *SRA Achievement Series: Science* for 1958 and Part I of the same examination for 1959, are significant at the 1% level. One involving Part II of the *SRA Achievement Series: Science* in 1959, and another, the specialized science examinations in 1960, are significant at the 5% level. Although it is not possible to generalize from these four cases, nevertheless it seems evident that the success of the students in science seems to have a higher relationship to the teachers graduate science training than to the teachers undergraduate science training.

Relationships Between Science Achievement and the Science Teachers Recent Science Training

In the computations summarized in Tables C through CVIII the effects of the recency of the science training of the teachers on student achievement in science was studied. The teachers were categorized in two groups, those whose most recent formalized science training had been completed within five years prior to the class in which the student was enrolled, and those whose most recent training was more than five years old. The results of the computations of these analyses of covariance follow.

Table C

Analysis of Covariance Between Teachers Recent Hours and Part I *Science* (1957) with *PMA* I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1230	949200.8900		
Within	1157	874236.4900	755.6063	
Difference	73	74964.4000	1026.9095	1.3590

F= 1.3590 is significant at the 1% level

Table CI

Analysis of Covariance Between Teachers Recent Hours and Part II *Science* (1957) with *PMA* I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	344	517416.8700		
Within	323	485538.7000	1503.2157	
Difference	21	31878.1700	1518.0080	1.0098

F= 1.0098 There is no significant difference

Table CII

Analysis of Covariance Between Teachers Recent Hours and Part I *Science* (1958) with *PMA* I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1658	991395.4000		
Within	1574	924502.1300	587.3584	
Difference	84	66893.2700	796.3484	1.3558

F= 1.3558 is significant at the 1% level

Table CIII

Analysis of Covariance Between Teachers Recent Hours and Part II *Science* (1958) with *PMA* I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1255	1188502.4000		
Within	1229	1136504.0000	924.7388	
Difference	26	51998.4000	1999.9384	2.1627

F= 2.1627 is significant at the 1% level

Table CIV

Analysis of Covariance Between Teachers Recent Hours and Part I *Science* (1959) with *PMA* I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1264	710166.8700		
Within	1182	653683.0500	553.0313	
Difference	82	56483.8200	688.8270	1.2455

F= 1.2455 is significant at the 5% level

Table CV

Analysis of Covariance Between Teachers Recent Hours and Part II Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1545	2937613.7000		
Within	1506	2794757.8000	1855.7488	
Difference	39	142855.9000	3662.9717	1.9738

F= 1.9738 is significant at the 1% level

Table CVI

Analysis of Covariance Between Teachers Recent Hours and Scores in Specialized Science Courses (1960) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	485	490082.0100		
Within	424	327272.2000	771.8683	
Difference	61	162809.8100	2669.0132	3.4578

F= 3.4578 is significant at the 5% level

Table CVII

Analysis of Covariance Between Teachers Recent Hours and Scores in Specialized Science Courses (1961) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	399	1565806.8000		
Within	318	1242550.6000	3907.3918	
Difference	81	323256.2000	3990.8172	1.0213

F= 1.0213 There is no significant difference

Table CVIII

Analysis of Covariance Between Teachers Recent Hours and Scores in Specialized Science Courses (1962) with *TEA* Total (1961) Held Constant

Source	DF	SS	MS	F
Total	43	27262.3090		
Within	18	7844.6333	435.8129	
Difference	25	19417.6760	776.7070	1.7822

F= 1.7822 There is no significant difference

An examination of Tables C through CVIII indicates that the recency of the science training of science teachers is related to the science achievement of students at the junior-high-school level. The relationship was particularly evident for the scores obtained on *Part I* of the *SRA Achievement Series: Science* in 1957-58, 1958-59 and 1959-60. Students who had teachers whose most recent training, either undergraduate or graduate, had been completed within five years scored significantly better on *Part I* than students who had science teachers whose most recent science training was more than five years old. Two of the differences were significant at the 1% level and one at the 5% level. Significant differences were evidenced for *Part II* of the science examination for 1958-59 and 1959-60, both at the 1% level. No significant difference was noted for the Part II scores for 1957-58.

Surprisingly, recency of science training of science teachers was not markedly related to science achievement of high-school students. It was noted that for 1960-61 students who had teachers with science training within five years scored better on the specialized tests than students whose teachers did not have science training within five years. The difference was significant at the 5% level. The differences for 1961-62 and 1962-63 were not significant.

Obviously it is difficult to postulate causation for the observed differences between the junior-high-school and high-school results. However, one may suggest that the content of the more specialized sciences at the high school level has tended to remain static and consequently the recency of the teachers' science training does not exert a significant influence on student achievement. Conversely, in the junior high school where the content of the science programs has been considerably less fixed, the more recent training may exert a positive influence. It should be noted that this hypothesis is not supported by tangible evidence from this study.

Relationships Between Science Achievement and Personality Characteristics of Teachers

A matter of interest in Science Motivation Project I was the relationship that might exist between certain personality factors of the science teacher and student achievement in science. It was not possible of course to require that science teachers in the participating schools take a personality inventory. However during the first two years of the Project the teachers of junior-high-school science were requested to take the Personal Audit: Form LL to assess certain of their personality characteristics. More than two-thirds agreed to do so. The Personal Audit consists of nine parts listed as follows.

Part I	Seriousness - Impulsiveness
Part II	Firmness - Indecision
Part III	Tranquillity - Irritability
Part IV	Frankness - Evasion
Part V	Stability - Instability
Part VI	Tolerance - Intolerance
Part VII	Steadiness - Emotionality
Part VIII	Persistence - Fluctuation
Part IX	Contentment - Worry

In analysing the data from the *Personal Audit*, the interpretation in the *Manual of Directions* that scores above the 75th percentile are considered "high" and scores below the 26th percentile "low" was used. Using these "cutting" scores as criteria, analyses of covariances were computed between mean scores of science students of "high" teachers on the *Personal Audit* and those of students who had "low" teachers on the *Personal Audit* holding I.Q. constant.

Because of an insufficient number of low and high scores for teachers on Parts II, III, V, VI, and VII of the *Personal Audit* for 1957-58, analyses of covariance were not computed. For the same reason computations were not made for Parts III, V and VI for 1958-59. The computations that were made are found in Tables CIX through CXXVIII.

Table CXXIX summarizes the significances of the differences from the computations that appear in Tables CIX through CXXVIII.

Table CIX

Analysis of Covariance Between Personal Audit Part I (Seriousness-Impulsiveness) and Part I *Science* (1957) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	119	175195.5700		
Within	74	113593.0400	1535.0410	
Difference	45	61602.5300	1368.9451	.8917

F= .8917 There is no significant difference

Table CX

Analysis of Covariance Between Personal Audit Part IV (Frankness-Evasion) and Part I *Science* (1957) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	112	545.4262		
Within	66	366.8147	5.5577	
Difference	46	178.6114	3.8828	.6986

F= .6986 There is no significant difference

Table CXI

Analysis of Covariance Between Personal Audit Part VIII (Persistence-Fluctuation) and Part I *Science* (1957) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	109	83.7689		
Within	61	46.0694	.7552	
Difference	48	37.6994	.7854	1.0399

F= 1.0399 There is no significant difference

Table CXII

Analysis of Covariance Between Personal Audit Part IX (Contentment-Worry) and Part I Science (1957) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	173	163400.4800		
Within	124	116167.3400	936.8333	
Difference	49	47233.1400	963.9416	1.0289

F= 1.0289 There is no significant difference

Table CXIII

Analysis of Covariance Between Personal Audit Part I (Seriousness-Impulsiveness) and Part II Science (1957) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	119	175195.5700		
Within	102	135043.3200	1323.9541	
Difference	17	40152.2500	2361.8970	1.7839

F= 1.7839 is significant at the 5% level

Table CXIV

Analysis of Covariance Between Personal Audit Part IV (Frankness-Evasion) and Part II Science (1957) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	112	545.4262		
Within	95	481.2913	5.0662	
Difference	17	64.1348	3.7726	.7446

F= .7446 There is no significant difference

Table CXV

Analysis of Covariance Between Personal Audit
Part VIII (Persistence-Fluctuation) and Part II
Science (1957) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	109	83.7689		
Within	93	71.8803	.7729	
Difference	16	11.8886	.7430	.9613

F= .9613 There is no significant difference

Table CXVI

Analysis of Covariance Between Personal Audit
Part IX (Contentment-Worry) and Part II Science
(1957) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	307	180483.5800		
Within	288	171831.2900	596.6364	
Difference	19	8652.2900	455.3836	.7632

F= .7632 There is no significant difference

Table CXVII

Analysis of Covariance Between Personal Audit
Part I (Seriousness-Impulsiveness) and Part I
Science (1958) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	317	551526.0200		
Within	251	411858.6300	1640.8710	
Difference	66	139667.3900	2116.1725	1.2896

F= 1.2896 is significant at the 5% level

Table CXVIII

Analysis of Covariance Between Personal Audit
Part II (Firmness-Indecision) and Part I *Science*
(1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	222	217950.3900		
Within	163	154940.1800	930.5532	
Difference	59	63010.2100	1067.9696	1.1235

F= 1.1235 There is no significant difference

Table CXIX

Analysis of Covariance Between Personal Audit
Part IV (Frankness-Evasion) and Part I *Science*
(1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	547	2344.0509		
Within	468	2007.6605	4.2898	
Difference	79	336.3904	4.2581	.9925

F= .9925 There is no significant difference

Table CXX

Analysis of Covariance Between Personal Audit
Part VII (Steadiness-Emotionality) and Part I
Science (1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	205	1833.4017		
Within	138	1357.7980	9.8391	
Difference	67	475.6037	7.0985	.7214

F= .7214 There is no significant difference

Table CXXI

Analysis of Covariance Between Personal Audit Part VIII (Persistence-Fluctuation) and Part I Science (1958) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	420	1618.2713		
Within	344	1263.2570	3.6722	
Difference	76	355.0143	4.6712	1.2720

F= 1.2720 is significant at the 5% level

Table CXXII

Analysis of Covariance Between Personal Audit Part IX (Contentment-Worry) and Part I Science (1958) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	289	1029.1311		
Within	228	802.5853	3.5201	
Difference	61	226.5458	3.7138	1.0550

F= 1.0550 There is no significant difference

Table CXXIII

Analysis of Covariance Between Personal Audit Part I (Seriousness-Impulsiveness) and Part II Science (1958) Holding PMA I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	317	551526.0200		
Within	288	523922.5900	1819.1756	
Difference	29	27603.4300	951.8424	.5232

F= .5232 There is no significant difference

Table CXXIV

Analysis of Covariance Between Personal Audit
Part II (Firmness-Indecision) and Part II *Science*
(1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	222	217950.3900		
Within	194	193035.9400	995.0306	
Difference	28	24914.4500	889.8017	.8942

F= .8942 There is no significant difference

Table CXXV

Analysis of Covariance Between Personal Audit
Part IV (Frankness-Evasion) and Part II *Science*
(1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	547	2344.0509		
Within	515	2235.2794	4.3403	
Difference	32	108.7715	3.3991	.7831

F= .7831 There is no significant difference

Table CXXVI

Analysis of Covariance Between Personal Audit
Part VII (Steadiness-Emotionality) and Part II
Science (1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	205	2495.4506		
Within	175	1974.7879	11.2845	
Difference	30	520.6627	17.3554	1.5379

F= 1.5379 is significant at the 5% level

Table CXXVII

Analysis of Covariance Between Personal Audit Part VIII (Persistence-Fluctuation) and Part II *Science* (1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	420	1618.2713		
Within	389	1546.1449	3.9746	
Difference	31	72.1264	2.3266	.5853

F= .5853 There is no significant difference

Table CXXVIII

Analysis of Covariance Between Personal Audit Part IX (Contentment-Worry) and Part II *Science* (1958) Holding *PMA* I.Q. (1957) Constant

Source	DF	SS	MS	F
Total	289	1029.1311		
Within	260	911.1067	3.5042	
Difference	29	118.0244	4.0698	1.1613

F= 1.1613 There is no significant difference

An analysis of the computations in Tables CIX through CXXVIII and the summation in Table CXXIX fails to elicit any conclusive evidence about relationships between personality factors measured by the *Personal Audit* and science achievement. For Parts II, III, V, VI and VII of the *Personal Audit* in 1957-58, there weren't enough teachers below the 26th percentile to make comparisons possible. The same was true for Parts III, V and VI of the Personal Audit in 1958-59. Of all the computations that were made, only four were significant at the 5% level. Students who had "serious" science

Table CXXIX

Summary of Significances of Differences of Computations Involving The Personal Audit and SRA Achievement Series: Science

Part of Personal Audit	SRA Achievement Series: Science			
	1957-58		1958-59	
	Part I	Part II	Part I	Part II
Seriousness-Impulsiveness	$P > .05$	$.01 > P > .05$	$.01 > P > .05$	$P > .05$
Firmness-Indecision	-	-	$P > .05$	$P > .05$
Tranquillity-Irritability	-	-	-	-
Frankness-Evasion	$P > .05$	$P > .05$	$P > .05$	$P > .05$
Stability-Instability	-	-	-	-
Tolerance-Intolerance	-	-	-	-
Steadiness-Emotionality	-	-	$P > .05$	$.01 > P > .05$
Persistence-Fluctuation	$P > .05$	$P > .05$	$.01 > P > .05$	$P > .05$
Contentment-Worry	$P > .05$	$P > .05$	$P > .05$	$P > .05$

teachers, performed significantly better on Part II of the SRA Achievement Series: Science in 1957-58 and on Part II in 1958-59 than did students who had "impulsive" teachers.

In 1958-59 the "persistent" teacher seemed to be a better science teacher in so far as Part I of the examination was concerned than the "fluctuating" teacher; and the "steady" teacher seemed to be more effective than the "emotional" science teacher in so far as Part II was concerned. If these separate conclusions are synthesized, it may be suggested that the factor of "stability" does seem to have some effect on science achievement at the seventh- and eighth-grade levels.

Relationships Between Numbers of Semesters Enrolled in Junior-High-School Science and Science Achievement

An effort was made to determine the effect of the total number of semesters of science in which the student participants were enrolled in grades seven, eight and nine and the scores they received on the SRA Achievement Series: Science. Computations for analyzing these relationships were made between Parts I and II of the examination and their enrollments in science courses at these grade level, holding mental ability as measured by the PMA I.Q. constant.

During 1957-58 a student may have (1) had no science, (2) taken it only in the first semester, (3) taken it only in the second semester, or (4) enrolled in it both semesters. Therefore, the analyses of covariance were computed on the basis of these four variables. For 1958-59 the combination of possibilities of "exposure to science courses" were based on the students having had (1) no science in the seventh grade, (2) one semester of science in the seventh grade, (3) two semesters of science in the seventh grade, (4) no science in the eighth grade, (5) one semester of science in the eighth grade, or (6) two semesters of science in the eighth grade. These reduced to six variables. For the ninth grade these variables were reduced to the possibilities of one, two, three or four semesters of science in the eighth grade and one year of science in the ninth grade for a possibility of five variables. Tables CXXX through CXXXVI contain the computations for these analyses of covariance.

Table CXXX

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-58 and Part I Science (1957) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1722	1518112.3000		
Within	1718	1446935.2000	842.2207	
Difference	4	71177.1000	17794.2750	21.1278

F= 21.1278 is significant at the 1% level

Table CXXXI

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-58 and Part II Science (1957) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1723	26358.2810		
Within	1719	24630.9410	14.3286	
Difference	4	1727.3400	431.8350	30.1378

F= 30.1378 is significant at the 1% level

Table CXXXII

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-59 and Part I Science (1958) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1706	331858.2200		
Within	1700	314533.4900	185.0197	
Difference	6	17324.7300	2887.4550	15.6062

F= 15.6062 is significant at the 1% level

Table CXXXIII

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-59 and Part II Science (1958) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1706	48139.2130		
Within	1700	46381.1580	27.2830	
Difference	6	1758.0550	293.0091	10.7396

F= 10.7396 is significant at the 1% level

Table CXXXIV

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-59 and Part II Science (1958 Rescored) with PMA I.Q. (1957) Held Constant

Source	DF	SS	MS	F
Total	1706	29530.6030		
Within	1700	28294.7960	16.6439	
Difference	6	1235.8070	205.9678	12.3749

F= 12.3749 is significant at the 5% level

Table CXXXV

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-60 and Part I Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1183	294816.8900		
Within	1178	233605.9900	198.3072	
Difference	5	61210.9000	12242.1800	61.7333

F= 61.7333 is significant at the 1% level

Table CXXXVI

Analysis of Covariance Between Semesters of Junior-High-School Science 1957-60 and Part II Science (1959) with PMA I.Q. (1959) Held Constant

Source	DF	SS	MS	F
Total	1183	102770.4400		
Within	1178	86036.0600	73.0357	
Difference	5	16734.3800	3346.8760	45.8252

F= 45.8252 is significant at the 1% level

An examination of the computations in Tables CXXX through CXXXVI indicates that the greater the exposure a student has to science courses and science teachers the greater his achievement. Postive differences in achievement were found among the group of students whenever the total exposure increased. This finding applies to both Parts I and II of the SRA Achievement Series: Science. The differences were significant at the 1% level except for one case which was significant at the 5% level. Despite the fact that the greater increment of achievement, as indicated earlier occurs at the eighth grade level, significant increments of achievement are noted for each successive semester of exposure to science at the seventh, eighth and ninth grade levels.

The Relationships Among Recency of Science Training of Teachers, and the Science Interest and Science Achievement of Students

An analysis was made to determine the numbers of students who ranked in the 75th percentile or above on science interest on the Kuder Preference Record and also met the two other conditions listed below:

1. Had one, two and three science teachers in sequence in 1957-58, 1958-59 and 1959-60 who ranked in the upper 25 percent of all the teachers in terms of the numbers of recent hours elected in science.
2. Ranked in the upper 25 percent on scores on the SRA Achievement Series: Science in each of these years.

Table CXXXVII below summarizes the results of this analysis.

Table CXXXVII

Students in Upper Quarters of Science Achievement and Interest with Teachers in Upper Quarter in Recency of Training

Years	Numbers of Students who Scored in Upper Quarter on Science and who met conditions 1 and 2
1957-58	57
1957-59	9
1957-60	7

As indicated in Table CXXXVII the numbers of students who met all three conditions are too small to suggest that the interrelationships among all three are high. Apparently, although recency of training does, as indicated earlier have some positive relationship to student achievement in science it is not accompanied with similar relationships to interest.

Maintenance of Performance

The final analysis in this phase of the Project, concerning maintenance of performance, bore a less tangible relationship to the teacher factor than others already dealt with. However, it was thought to be sufficiently pertinent to consider here. The analysis involved the numbers of students in the upper and lower quarters of science achievement in 1959-60 who maintained that performance through 1960-61, 1961-62 and 1962-63 in the specialized sciences. Table CXXXVIII contains the tabulations.

Table CXXXVIII

Maintenance of Performance in Upper and Lower Quarters of Science Achievement

Period	Numbers in Upper Quarter in 1959 Maintaining Position		Numbers in Lower Quarter in 1959 Maintaining Position	
	Part I	Part II	Part I	Part II
1960-61	722	772	308	258
1960-62	175	179	124	103
1960-63	85	51	71	63

The data in Table CXXXVIII indicate that the relative percentage of students who maintain position in the upper quarter of science achievement is less than that of students who maintain their relative positions in the lower quarter. One may conclude therefore, that low achievement in junior-high-school science, without regard for the reason, seems to be more predictive of sustained low achievement in later specialized courses, than sustained high achievement in junior-high-school science is predictive of later high achievement. One may suggest that a lack of knowledge from junior-high-school science may be more depressing on later science achievement, the success in junior-high-school science is likely to foster later science achievement.

Summary

Certain positive relationships are evidenced in this section between various teacher factors and student achievement. Yet, it is difficult to establish that any factors operate independently. Some of the implications of the coexistencies will be discussed in the concluding chapters.

CHAPTER IX

SUMMARY AND CONCLUSIONS

The Purpose

This long-term investigation, referred to as Science Motivation Project I, and which extended from 1957 through 1963, was an effort to identify the factors that (1) may be related to the achievement in science of students in junior- and senior high schools; and (2) motivate students to elect courses in science at these levels. In order to obtain the data needed, students who entered the seventh grade in the Fall 1957 in the school systems of Rockford, Kankakee and Wilmington, Illinois; Angola, Elkhart and Kendallville, Indiana; Archbold and Bryan, Ohio; Marshall, Quincy and Kalamazoo, Michigan; and the University High School, Western Michigan University were enlisted as subjects from that time through their senior years in high school.

Numerous measurements were made during the Project, among them, the mental ability, reading ability, educational plans, interests and science achievement of the students; the academic backgrounds and personality factors of the teachers; and certain characteristics of their families, school systems and communities. The data collected were analyzed for answers to the following questions:

1. What factors of intelligence are related to subject-matter achievement in the sciences?
2. To what extent is interest in science related to those factors of intelligence that seem to foster achievement in the sciences?

3. To what extent does the subject-matter training of the junior-high-school teacher influence students to elect courses in science in high school in the area in which the junior-high teacher is best trained?

4. What factors in the personality of the teacher of science seem to motivate students to elect courses in science in high school?

5. To what extent is achievement in junior-high-school science related to achievement in courses in high-school science?

6. To what extent does achievement in junior-high-school science seem to influence students to elect courses in high-school science?

7. How does general students interest in science change from the sixth-grade level through the high-school level?

The computations that were made and many conclusions that were drawn are found in the preceding chapters. Not all of these conclusions will be repeated here. Rather in this chapter some of the more important conclusions will be discussed, others will be presented, and implications will be drawn in so far as they may be defensible. It was not possible from the data that were obtained to answer all the questions listed above. Yet, it was possible to answer a number of important questions not originally posed.

The conclusions and implications have been grouped arbitrarily under what seem to be appropriate headings. These headings are _Science achievement and the school_; _Student factors_; _Home, school and community factors_; and _Teacher factors_.

Science achievement and the schools

1. During 1957-58, 1958-59 and 1959-60, the first three years

of the Project, all the participating students in the seventh, eighth and ninth grades were administered science tests to measure their accomplishments in the junior-high-school science programs. At the time, no suitable standardized test was available, except for the SRA Achievement Series: Science which was in preparation. This test was selected because, in the opinion of the Director of the Project and some of his colleagues, it evidenced face validity. As part of the Project, an effort was made to determine the reliability and validity of both Parts I and II of the test using acceptable techniques. These techniques are described on pages 25 through 27 of this report. The results of these computations indicated that the SRA Achievement Series: Science evidenced the reliability and validity expected of tests used for such purposes. Consequently their use seemed to be justified.

2. An examination of the scores made by the students, indicates that in most of the school systems there is a regression in science achievement between grades eight and nine. In only three of the thirty-six pertinent measurements were the mean gains between the eighth and ninth grades greater than those between the seventh and eighth grades. Thus, science instruction seems to be most effective during the second year of the junior-high-school science program. This observation applies without regard for the ranges in which the scores of students in the different school systems fell.
Frequent visits to the participating schools confirm the claim that ninth-grade science is often a "rehash" of the experiences in the

seventh and eighth grades. Thus, the science programs at the ninth-grade level often fail to give the student opportunity for growth. However, in some of the schools the general science taught in the ninth grade was a mature course in which student growth was evident. Consequently, the "rehash" doesn't have to be that way.

3. In three schools the mean scores obtained on Part II in 1959-60 was lower than that for 1958-59. None of these losses could be attributed to faulty test administration. An investigation revealed that in one school, students elected Biology rather than general science in the ninth grade. Thus, the experiences in Biology in that school apparently were not equivalent to those in general science in so far as achievement on Part II was concerned. In the second school the mean loss (.01 point) did not seem worthy of investigation.

   In the third school the general-science program in the ninth grade practically duplicated that of the eighth grade. Earlier visits by the Director to that school indicated much apathy in the ninth-grade science classes, which may account for the loss.

4. There is little evidence to show that gains in factual knowledge in science are accompanied with commensurate gains in the ability to make use of, or interpret, the concepts related to that knowledge. The data showed that there is only a modest relationship between factual achievement and the ability to do qualitative thinking. The relationship increased chiefly with increased exposure to science. It was noted, however, that the greatest gain in conceptual

understanding and related abilities as measured by Part II of the SRA Achievement Series: Science appeared in those schools in which demonstrations and individual laboratory activity accompanied the science courses.

5. The various analyses in this study indicate that many factors are related to science achievement. No single factor was shown to be so influential as to negate the importance of others. A matrix of many factors seems to be responsible for the overall achievement of the students.

   However, independent of other factors, achievement in the specialized science courses in the high school seems highly related to the experiences of the students in junior-high-school science. In general, science achievement increases with the total exposure students have with general science in the junior-high-school. The greater the number of semesters elected, the higher their scores. There are exceptions and the increment of achievement is tempered by other factors. Nevertheless the more science a student elects the more he is likely to achieve. There seems to be no terminal point at which students should be advised that they cannot profit from additional study of science.

   Also, the level of achievement in junior high school science is highly related to that in the specialized science courses elected later. This is especially true for the lower achievers in science in the junior high school.

Student factors

1. Science achievement, either in terms of factual knowledge or conceptual understanding is only moderately related to mental ability. The greatest degree of relationship seems to be with the verbal factor of mental ability. Yet even here most of the coefficients of correlation range between .40 and .66 which is only slightly more than twenty percent above chance. Factors other than intelligence seem to have a much greater relationship. In those analyses in which comparisons were made between the factors of mental ability and science achievement, holding reading ability constant, the relationships were shown to be high and significant. Thus the relationship of reading ability to science achievement was further confirmed.
2. Achievement in both science and mathematics at all grade levels involved in this study, is related significantly to various facets of reading ability. This finding was supported both directly and indirectly. The least degree of relationship exists with the rate at which the student reads, and the greatest degree with the students ability to comprehend what he reads and his knowledge of vocabulary. Therefore it seems reasonable to suggest that science teaching should not stress the volume of materials in science or mathematics read in a certain unit of time. Rather emphasis should be placed on the thoroughness to which the student undertakes his reading activity. This conclusion applies without regard for the mental ability of the student, or the extent of his knowledge of facts or concepts of science and mathematics.

3. In eight of the participating schools the problems of adjustment professed by the students in the seventh grade (1957-58) declined significantly during the eighth grade (1958-59). These problems were related to social, personal, school and family adjustment. In four schools, however, in which the advent of Sputnik resulted in a "lay it on" philosophy the numbers of problems professed by the students increased significantly. In these four schools the average gain in science achievement, both factual and conceptual was less than the average gain of the other eight schools. The pressure apparently produced less achievement and more frustration. Further these "losses" had some negative effect in achievement in the specialized science courses elected in the high school. One may reasonably conclude that "crash programs in science" at the high school level, even with qualified science teachers do not retrieve the losses from pedagogical efforts that may be ill advised.
4. It was interesting to note that students who elected special course offerings in science (i.e., general physical science, etc.), or who elect the usual courses out of the regular sequence are not generally among those who express strong intentions, at least at the ninth-grade level, of attending college. Yet many of these students who later elected science courses out of the regular sequence were among the high achievers. This suggests that college aspirations expressed at the ninth-grade level may not be a satisfactory criterion for identifying those students who may profit from electing the specialized science courses.

5. The data concerning the aspiration levels of the students are somewhat anomalous. Many ninth-grade students do not express realistic attitudes toward their limitations. Forty percent (40%) of those students with IQ's below 75 expressed a definite intention to attend college; 44% of those with IQ's between 76 and 92; and 64% of those between 93 and 109 did likewise.

   Those students at the ninth-grade level who have low aspirations concerning further education are generally lower science achievers than students who have high levels of aspiration. Nevertheless, many of the students with low aspirations at the ninth-grade level, and who elect specialized courses at the twelfth-grade level are among the highest achievers. This is further evidence of the dubious wisdom of using statements of educational or occupational aspiration at the ninth-grade level as devices for counseling students into, or out of, the specialized science courses in the high school. The counseling program should recognize that aspirations and the likelihood of achievement in the specialized science courses may change greatly.

6. Lack of adjustment, particularly in the area of school adjustment, seems to be highly related to the mental abilities of students. In this study, students of low mental ability generally found the school environment to be unfavorable. However, despite the fact that most of them were significant, none of the relationships between science achievement and adjustment were sufficiently high to warrant using factors of adjustment as predictors of science achievement _for_

individuals. On a group basis, however, it was found definitely that the high science achievers had significant numbers in the "high-adjustment category" where the low science achievers were much more likely to be in the "low-adjustment category." These group disparities increase as students progress through the junior high school. It is likely that many interrelated factors, particularly lack of scholastic achievement cause a general dissatisfaction with the school and this produces a halo effect of general dissatisfaction with all education.

7. It was particularly worthy of note that the accepted stereotypes of interest patterns for high science achievers was not supported in this study. Generally it is assumed that the high science achievers have fairly fixed patterns of interest in the Scientific, Mechanical and Computational areas. These patterns of interest did not appear. The high achievers in the sciences frequently had pairings of high areas of interest such as Social Science-Clerical, Outdoor-Scientific, Clerical-Scientific and so on. The Scientific area does appear generally among the high science achievers.

Home, school and community factors

1. A synthesis of the data concerning the home environment indicates clearly that students who come from families that express a concern about the future occupational plans of their children, score higher on science examinations than students from families where this concern is not expressed. This conclusion is limited by the belief

on the part of the student that such concern exists. As in other studies this study indicates that there is a high degree of relationship between the educational attainments of the father and the science achievement of the student. However in this study, the educational attainment of the mother seems to be more closely related to science achievement than that of the father. If both had high educational attainments, the science achievement of the student showed further increments. Individual analyses indicated that without regard for the mental ability, students generally performed above expectancies in science if their families fell among the "high concern" groups. Also, students generally performed below expectancies if their families fell among the "low concern" groups.

2. Many students in grade nine through twelve who elect non-required specialized science courses, and who have indicated positively that they did not intend to go into college scored significantly better on both science and mathematics examinations than students who stated they "definitely will" or "all most sure to go." The mean intelligence scores of the former group did not differ significantly from those of the latter. However in more than 90% of the former cases, parental sentiment toward advanced study was not professed by the student.
3. Between the seventh and ninth grades, for students who scored in the upper twenty-five percent in terms of professed problems related to school, home and community there was an average loss of 1½ points in IQ; whereas for those students in the lower 25% of professed problems,

there was an average gain of about 1½ points. These findings involved the same students over the three-year span. The average IQ of the "upper 25% in problems" in the seventh grade was 94+, and in the ninth grade, 93-. At the seventh-grade level the average IQ for the "lower 25% in problems" was 102-, and in the ninth grade, 104+. Between the seventh and eighth grades the average gain of the upper 25% (poor adjustment) for factual knowledge in science was about 6 points, and for comprehension of science, about .5 points. The lower 25% (good adjustment) gained 10+ points on the former and about 1½ points on the latter. Obviously adjustment problems cannot be held wholly responsible for science achievement. Nevertheless such problems are far more prevalent with the lower achiever than with the high achiever.

4. Without regard for level of mental ability, of students, those students from families in which the fathers is a professional in an urban environment perform significantly better in science from the seventh grade through the high school, than students from rural environments. Students whose fathers are skilled workers or are in service occupations also perform better than students from rural families.

   When these phenomena were investigated, two factors seemed paramount:

   a. Among students from rural families the level of occupational aspiration is much less than that found in the urban family. Neither does the student profess that the father or mother are so concerned with his advanced education.

b. Teachers of science in rural schools neither have the extent or recency of science training that teachers from the larger urban or semi-urban schools seem to have. Even with more time devoted to science, rural students do not fare so well with the less well-trained teacher, as do urban students who spend less time in science classes with better trained teachers.

5. In one school system, in which the gain in science achievement was relatively high between the seventh and eighth grade, there was a markedly lower gain between the eighth and ninth grades. Although this disparity was found in many schools, it was much greater in this one. However, the science program seemed satisfactory to the Director, and the mean IQ's of the students were practically the same both years.

   Investigation revealed, however, that a new "culturally deprived" group had joined the eighth grade class when it moved into the ninth grade. The levels of educational and occupational aspiration were much lower than for the original group, despite the "maintenance of IQ." When the data were analyzed using only those students who were in the original eighth-grade group, the mean gain almost equaled that for the previous year.

Teacher factors

1. Among the more important findings about the influence of the teacher was that neither the total, on science achievement nor distribution, of the undergraduate hours of science elected by the science teacher bore much relationship to student achievement in science. There

seemed to be little difference in achievement whether the teachers major training was in the biological, earth or physical sciences. However, it was generally evident that the recency of the teachers science training, and the number of graduate hours elected in the science were significantly related to student achievement. One may conclude that continuing in-service programs in science may well be the key to increased student achievement.

2. Personality factors of science teachers as measured by The Personal Audit seem to have little relationship to student achievement. Only one generalization could be drawn about relationship of personality factors, namely, that the general factor of teacher stability did seem to be related to science achievement at the seventh- and eighth-grade levels. However no specific conclusions could be drawn about individual personality factors. It might be suggested that most of the teachers fell within the normal range and consequently there were too few cases of deviants to elicit any useful data.

3. The undesirable influence of one teacher one science achievement was particularly noticeable. In one school the mean score of the students on Part I in 1959-60 was lower than that for 1958-59. The phenomenon could not be attributed to faulty test administration. Further, the scores used in this comparison were from the same students who were enrolled in general science both years. The phenomenon was investigated during several visits to the school. It was found that five of the six classes in ninth-grade general science were taught by a teacher with a "special certificate" who

had never elected a science course in college. The students in these classes regressed in science achievement between 1958-59 and 1959-60, in so far as test scores were concerned. The students in the sixth ninth-grade class had the same fairly-well qualified science teacher they had in the eighth grade. The mean gain of this single ninth-grade group nearly equaled the gain in the eighth grade.

4. Several analyses were attempted to determine whether the major areas in the science background of the science teachers might be reflected in the specialized science courses students elected. Also, one effort dealt with the possibility of science interest being a function of the training of the junior-high-school teacher. None of these analyses produced any tangible results. Hence there are no data about these efforts in the preceding chapters.

An Epilogue

In general, further conclusions that may be drawn from Science Motivation Project I must be left to those who undertake to read the report carefully. Many facts are presented; but the Director has been much to close to the people involved in the Project to avoid subjectivity. However in final summary, a few general conclusions, drawn from observations in the participating schools and the "objective data" collected, after seven years of effort, seem defensible:

1. If any one single factor could be selected as "the most influential" in science achievement it would be the aspirations and interest of the parents for education of their children.

2. Where "crash programs" and "laying it on" for better science achievement were attempted, inverse results were noted. Programs that were developed "over the long haul" resulted in much greater achievement.
3. Few of the characteristics measured in the junior high school could be used defensibly in counseling a student to take more, or avoid, science in the high school. The efforts frequently encountered to "pick scientists early" are dubious if the data in this study are valid.
4. Apparently there "is no such thing" as a teacher with a "permanently satisfactory science background." The role of continued upgrading of science teachers backgrounds in science may be greatly underestimated.
5. There seems to be no one "angle of attack" on the problems of improving science teaching and apparently no likelihood of respite. Science teachers may well heed the sage statement of the immortal Satchel Paige, "Don't look back, something may be gaining on you!"

APPENDIX A

State of Illinois

Dr. Vernon L. Nickell, Superintendent of Public Instruction

__Kankakee Public Schools__

Dr. Anthony Marinaccio, Superintendent of Schools (1956-59)
Mr. W. W. Knecht, Superintendent of Schools (1960-63)
Mr. Earl D. Patton, Director of Instruction (1957)
Mr. Stanley Weber, Supervisor of Instruction (1958-63)
Mr. Harold R. Hungerford, Junior High School Principal (1957-60)
Mr. Arthur Hasbargen, Jr., Director of Guidance (1961-63)

__Rockford Public School__

Dr. W. L. McIntosh, Superintendent of Schools (1956-63)
Mr. Harry Hulick, Principal, Lincoln Junior High School (1957-60)
Mr. J. W. Welsh, Principal, East Senior High School (1960-63)
Mr. Emery Fritsch, Head, Science Department, East Senior High School (1960-63)
Mr. Paul A. Johnson, Chairman, Science Department, Lincoln Junior High School (1957-60)
Miss Martha Deans, Sophomore Girls' Counselor (1960-61)
Mr. Robert Wood, Sophomore Boys' Counselor (1960-61)
Mr. Leonard Gibb, Junior Boys' Counselor (1961-62)
Miss Sue Patrick, Junior Girls' Counselor (1961-62)
Miss Bernice Zimmerman, Senior Girls' Counselor (1962-63)
Mr. Emil Berzinski, Senior Boys' Counselor (1962-63)

__Wilmington-Lorenzo Community Unit District 209 U__

Mr. Lester J. Stevens, Superintendent of Schools (1957-63)
Mr. Robert W. Jones, Principal (1957-61)
Mr. Charles Jenkins, Principal (1961-62)
Mr. Robert Medcalf, Guidance Director (1958-59)
Mr. Charles E. Endsley, Guidance Director (1960-62)
Mr. Edward Gladish, Guidance Director (1962-63)

State of Indiana

Mr. Wilbur Young, State Superintendent of Public Instruction

Angola Public Schools

Mr. W. H. Boomershine, Superintendent (1956-63)
Mr. F. K. McCutchan, Principal (1957-63)
Mr. Julius Milhollin, Director of Guidance (1960-63)

Elkhart Public Schools

Mr. J. C. Rice, Superintendent (1956-63)
Mrs. Audrey Russell, Director, Pupil Personnel and Guidance (1956-63)
Mr. C. P. Woodruff, Principal, Elkhart High School (1960-63)
Mr. Glenn H. Updike, Assistant Principal (1960-63)

Kendallville Public Schools

Mr. L. S. Brumbaugh, Superintendent (1956-58)
Dr. Lorin Burt, Superintendent (1959-60)
Mr. Edgar B. Redman, Superintendent (1961-63)
Mr. Royal W. Tritch, Principal (1957-63)
Mr. Keith Stouder, Guidance Director (1959-63)

State of Michigan

Dr. Lynn Bartlett, State Superintendent of Public Instruction

Kalamazoo Public Schools

Dr. Loy Norrix, Superintendent (1957-58)
Mr. Thomas Bowman, Superintendent (1958-61)
Dr. Richard N. Percy, Superintendent (1961-63)
Dr. John R. Cochran, Assistant Superintendent (1961-63)
Mr. Russell Doney, Director, Research and Pupil Personnel (1957-62)
Dr. Theral T. Herrick, Director of Curriculum (1957-62)
Mr. Thomas Szyperski, Director of Testing (1960-63)

University Campus School

Dr. Roy C. Bryan, Director, Campus School (1957-62)
Dr. Donald C. Weaver, Director, Campus School (1962-63)
Dr. Edward V. Perkins, Assistant Director, Campus School (1958-61)
Mr. Clarence Hackney, Director of Guidance (1957-63)

Marshall Public Schools

Mr. Harley Holmes, Superintendent (1956-60)
Mr. Bruce Gray, Superintendent (1960-63)
Mr. E. G. Rose, Principal, Marshall High School (1957-63)
Mr. William Crumrine, Assistant Principal and Director of Guidance (1957-63)

Quincy Public Schools

Mr. Newell Burt, Superintendent (1956-59)
Mr. Elwood Larsen, Superintendent (1959-63)
Mr. Dean VanLandingham, Principal (1957-58)
Mr. William Hanichen, Principal (1958-62)
Mr. Ronald Reynolds, Principal (1963)

State of Ohio

Mr. R. M. Garrison, Director of the Division of Elementary Education of the Department of Education of the State of Ohio

Archbold Public School

Mr. J. H. Spengler, Superintendent (1956-63)

Bryan Public Schools

Mr. H. W. Rogge, Superintendent (1956-63)
Mr. R. S. Hadley, Principal (1959)
Mr. Joseph Newell, Principal (1959-63)

APPENDIX B

Tests Used in Science
Motivation Project I

I. Intelligence Tests:

- A. SRA Primary Mental Abilities: Intermediate Form AM. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1948.
- B. SRA Tests of Educational Ability: Grades 9-12. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1957.

II. Reading Tests:

- A. Diagnostic Reading Tests: Survey Section: Form A. The Committee on Diagnostic Reading Tests, Inc., Mountain Home, North Carolina, 1952. (Distributed by Science Research Associates, 259 East Erie Street, Chicago, Illinois)

III. Interest Tests and Inventories:

- A. Kuder Preference Record: Vocational: Form CH. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1948.
- B. SRA Junior Inventory: Form A. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1951.
- C. Your Educational Plans: High School Edition. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1958.

IV. Achievement Tests:

- A. Commerical Tests:
    1. A.C.S. - N.S.T.A. Cooperative Examination: High School Chemistry: Form 1961. Examinations Committee - A.C.S. - University of South Florida, Tampa, Florida, 1961.
    2. ACS - NSTA Cooperative Examination: High School Chemistry: Form 1963. Examinations Committee - ACS, University of South Florida, Tampa, Florida, 1963.

IV. *Achievement Tests*:

A. Commerical Tests: (continued)

3. *Advanced Placement Examination*: *Biology* - *Section I*: *Form KBP*. Educational Testing Service, Princeton, N. J., 1962.

4. *Dunning Physics Test*: *Form AM*. Harcourt, Brace & World, Inc., New York, New York, 1950.

5. *Nelson Biology Test*: *Form AM*. World Book Company, Yonkers-on-Hudson, New York, 1950.

6. *SRA Achievement Series* - *Arithmetic*: *Form A* - *Grades 6-9*. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois.

7. *SRA Achievement Series* - *Science Part 1*: *1958 Experimental Edition*. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1958.

8. *SRA Achievement Series* - *Science Part 2*: *1958 Experimental Edition*. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1958.

9. *SRA Achievement Series* - *Science Part 2*: *1959 Experimental Edition*. Science Research Associates, Inc., 259 East Erie Street, Chicago, Illinois, 1959.

B. Non-Commercial Tests:

1. *Comprehensive Scholarship Examination in Science and Mathematics*: *1962 Edition*. Prepared for Western Michigan University, Kalamazoo, Michigan.

2. "Comprehensive Test in Earth Science." Prepared for Science Motivation Project I, 1962.

3. "Comprehensive Test in Earth Science and Human Biology." Prepared for Science Motivation Project I, 1960.

4. "Comprehensive Test in General Physical Science." Prepared for Science Motivation Project I, 1961.

5. "Final Examination." *Tests for General Physical Science*. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, New York, 1962.